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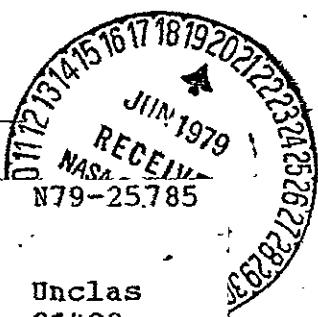
TIR 741-MED-3023

FROM	TO		
D. G. Fitzjerrell		J. A. Rummel, Ph.D.	
DATE	WORK ORDER REF:	WORK STATEMENT PARA:	REFERENCE:
4/10/73	DM-110T	NAS9-12932	
SUBJECT	Program for the Solution of Multipoint Boundary Value Problems of Quasilinear Differential Equations		

The program is designed to provide numerical solution of multipoint boundary value problems governed by a system of up to 20 first-order ordinary differential equations. This system of equations will be subject to a set of up to 20 boundary conditions. Linear equations are solved by a method of superposition of solutions of a sequence of initial value problems. For nonlinear equations and/or boundary conditions, the solution is iterative and in each iteration a problem like the linear case is solved. A simple Taylor series expansion is used for the linearization of both nonlinear equations and nonlinear boundary conditions. The perturbation method of solution is used in preference to quasilinearization because of programming ease, smaller storage requirements, and experiments indicate that the desired convergence properties exist although no proof of convergence is given. The use of this program for nonlinear differential equations is also applicable to the inverse problem of; given a model and an output, determine the system that gave this output. These are often called "parameter estimation" or "systems identification" problems.



D. G. Fitzjerrell



(NASA-CR-160208) PROGRAM FOR THE SOLUTION
OF MULTIPOINT BOUNDARY VALUE PROBLEMS OF
QUASILINEAR DIFFERENTIAL EQUATIONS (General
Electric Co.) 47 p HC A03/MF A01 CSCL 09B

N79-25785

Unclassified

G3/61 21422

CONCURRENCES

Counterpart:

Medical Projects Engr. & Advanced Programs
Unit Manager: CWFulcher Subsection Mgr. WJBeittel

DISTRIBUTION GE/AGS: Central Product File
R. C. Croston, Ph.D.
R. F. Hassell
B. G. Hall
V. J. Marks

NASA/JSC: Technical Library/JM6
(1979 Distribution)

Page No.
1 of 1

PROGRAM DESCRIPTION GUIDE

A. IDENTIFICATION

Program Name - MINIQUASI

Programmer's Name - V. J. Marks and B. G. Hall

Date of Issue - 4/9/73

B. GENERAL DESCRIPTION

The program is designed to provide numerical solution of multipoint boundary value problems governed by a system of up to 20 first-order ordinary differential equations. This system of equations will be subject to a set of up to 20 boundary conditions. Linear equations are solved by a method of superposition of solutions of a sequence of initial value problems. For nonlinear equations and/or boundary conditions, the solution is iterative and in each iteration a problem like the linear case is solved. A simple Taylor series expansion is used for the linearization of both nonlinear equations and nonlinear boundary conditions. The perturbation method of solution is used in preference to quasilinearization because of programming ease, smaller storage requirements, and experiments indicate that the desired convergence properties exist although no proof of convergence is given. The use of this program for nonlinear differential equations is also applicable to the inverse problem of; given a model and an output, determine the system that gave this output. These are often called "parameter estimation" or "systems identification" problems.

C. USAGE AND RESTRICTIONS

Machine and Compiler Required - Xerox Sigma 3
- ANSI FORTRAN

Peripheral Equipment Required - Card Reader and Line Printer

Approximate Amount of Memory Required - 13B3 hexadecimal (5043 decimal)

D. PARTICULAR DESCRIPTION

Equations Used and Derivations - See Reference 1

Definition of Terms Used - See Reference 1, Appendix A and B

Detailed Description - The program is designed such that a broad class of problems can be solved with a minimum amount of programming effort by the user. The only programming required by the

user is that which is involved with the description of the governing equations for a specific problem, and this task is completed within the framework of a subroutine furnished with the program package. All other pertinent information is communicated to the program by means of input data cards.

After setting up COMMON and DATA blocks, the main program begins execution by reading data to obtain values for certain key control parameters, boundary condition information, and estimates of initial values of the solution. This data is then reduced as follows: the boundary conditions are arranged in order of their occurrence with respect to the independent variable; the limits on the independent variable are changed if need be to span the boundary conditions; any initial conditions which were input as boundary conditions are placed in the initial value vector where they supersede any previous values. For each exact initial condition, the order of the system to be solved is reduced by one until the required number of solutions to be used in the superposition scheme has been determined. The perturbation factors are then checked to ensure that none of the perturbations are null, and the required matrix dimensions are calculated. Finally, an echo check of initial conditions, input data, and key program parameters is accomplished by outputting appropriate values.

Iterations

Next, up to a certain number of iterations are taken in an attempt to solve the problem as input. The initial values of the best estimate of the solution at each iteration are used to generate both the "previous approximation" and the particular solutions to be used in forming the next approximation. These solutions are started from initial values which are perturbed from those of the previous approximation in the manner already discussed. The integration of these initial value problems is undertaken by a fourth order Runge Kutta scheme especially adapted for the data structuring employed in QUASI. Integration starts at the minimum value of the independent variable and stops at the last prescribed boundary condition during intermediate iterations and at the maximum value during the final iteration. Output of integration results is controlled by the user through an input parameter.

The superposition of these solutions is implied by interrupting the integration whenever a boundary condition is encountered and setting one of the algebraic equations into a storage area for future use in determining the superposition constants. When all boundary conditions have been so set, a linear algebraic system is solved to obtain the solution as desired (exact fit or best fit in least squares sense). Following the determination of the constants, the best estimate of the initial values is updated according to the desired method and if convergence has not occurred, within the limiting number of iterations, a new iteration is begun. Convergence occurs whenever all of the constants of the perturbed solutions are smaller in absolute value than a preassigned value.

E. DESCRIPTION OF INPUT
(Extracted from Ref.1)

In order to utilize the program the user must successfully communicate a variety of descriptive and control information. There are two basic chores involved. The first consists of programming the system of equations into the structure of one of the FORTRAN subroutines. The second task involves the input of program control parameters, boundary value information; and other data necessary or desirable to a successful program execution.

Nonlinear System

Programming of Equations

The way in which the nonlinear system may be described in the RHS subroutine is as follows:

Denoting the previous approximation to the solution of the nonlinear system

$$\dot{y} = g(y, t)$$

as y_o , the linearized system can be written

$$\dot{y} = g(y_o, t) + \frac{\partial g(y_o, t)}{\partial y} (y - y_o)$$

where $\frac{\partial g(y_o, t)}{\partial y}$ denotes the Jacobian of the nonlinear system evaluated using the approximation y_o . Evaluating the indicated differences in current and previous approximations leads to a system of equations

$$\dot{y}_i = g_i(y_o, t) + \sum_{j=1}^N \frac{\partial g_i(y_o, t)}{\partial y_j} [y_j(t) - y_{o_j}(t)]$$

These equations can be programmed as above using the vector Y for the current solution and the vector Y_0 (or Y_0) for the previous approximation. Of course, the values of g_i and $\partial g_i / \partial y_i$ are to be computed using the previous approximation.

Linear System

The actual linear equations are placed in the RHS subroutine. No further statements are required.

1. Data Input

The input data is read by the program in four groups: integer control parameters, real control parameters, boundary value information, and initial conditions and related data. The input for each section is terminated by a blank record and the procedure is so structured to allow an arbitrary ordering of records in the input list and an arbitrary amount of data to be read in any one of the four groups. This input procedure is particularly convenient for multiple data sets for the same system of equations, because only that information to be changed need be included in the input list.

The integer and real control parameters have been included in two COMMON blocks, and input of values for these parameters is done by reference to the order of occurrence of a particular element in a COMMON block. This practice greatly simplifies input commands.

Integer Control Parameters

The elements of the integer COMMON block have been EQUIVALENCEd to elements of a vector of integer variables occupying the same storage location and can be referenced by name or by lineal subscript location within the vector. These elements are input by entering the vector subscript corresponding to the element location and the desired value of that element in the first two fields of a record. Listed below are the most commonly used input integer variables with the vector subscript as the key variable. The variables are all given a default value. If the value is not listed, it is zero. In most cases, the zero value is an ideal value. The format for integer input is

FORMAT (215)

<u>ELEMENT NUMBER</u>	<u>DESCRIPTION</u>
1	output control parameter. Zero default. = 0 gives minimal output. This includes the initial conditions of each iteration and the superposition constants. On the final iteration the unperturbed or nonlinear solution is output. = 1 adds to the above output the initial condition change that would be taken if the change is unconstrained, the cartesian length or norm of this vector and the dot product of successive unit vectors parallel to the changes. The matrix in which the boundary conditions and results of the boundary condition operators on the perturbed solutions is also output. = 2 adds to all the above output, the pivotal elements used in solving for the superposition. = 3 adds the unperturbed or nonlinear solution to the above output. = 4 adds the perturbed solutions to the above output.
2	= 0 for nonlinear problem. Zero default. = 1 for linear problem.
3	See Appendix D for explanation. Zero default.
4	= maximum number of recurrence iterations. Default value = 5.

<u>ELEMENT NUMBER</u>	<u>DESCRIPTION</u>
5	= 0 keeps a constant maximum value for the norm of the change of the initial condition vector. Zero default. 0 allows the maximum value for the norm of the change of the initial condition vector to be reduced to the smallest norm encountered.
6	= total number of boundary conditions to be imposed on the system. Must be input except on initial value problems.
7	= number of dependent variables in the problem which have non-null derivative expressions. Must be input because default is meaningless.
8	= number of dependent variables which do have null derivative expressions; i.e., constants to be identified. These are the last elements of the state variable vector. Zero default.
9	output control parameter which gives frequency at which output of information about the solution is to occur. It refers to the nominal number of integration steps between regular output points. It should be noted that output will also occur at points where boundary conditions have been specified. Default value = 5.
10	# 0 causes the original initial conditions to be saved for use with subsequent data sets. = 0 the subsequent data sets will use the last information then available for initial conditions. Zero default.
11	used to signal computation and output of the Wronskian of the solution. Zero default. ≤ 0 no computation = 1 computation only at end of integration on final solution. > 1 computation each time a boundary value is encountered during solution.

The remaining elements in the integer COMMON block are established during execution and need not be input. A blank record should follow at this point to terminate integer input.

Real Control Parameters

The parameters in the real COMMON block are input in the same manner as those in the integer COMMON block (except, of course, for different field specifications). The vector subscript is again the key variable and is listed below with the corresponding parameter description. The format for real parameter input is

FORMAT (15,G15.7)

<u>ELEMENT NUMBER</u>	<u>DESCRIPTION</u>
1	the nominal integration step size to be used--default value = 0.1.
2	a standard perturbation factor to be applied to all unknown initial value estimates unless otherwise specified--default value = 1.2.
3	the maximum value of the "length" of the change in the initial value vector--if input as zero, will override 5th element of integer COMMON block being non-zero and allow unrestricted changes. Zero default.
4.	the initial value of the range of the independent variable. It is set to the smaller of (zero or the input value) or the smallest time of a boundary condition.
5	the final value of the range of the independent variable. It is set to the larger of (zero or the input value) or the largest time of a boundary condition. Must be input for initial value problems.
6	a scale factor for the determinant of the coefficient matrix used in calculating the superposition constants. Default value is unity.
7,8	small parameters which need not be input.
9,10	parameters which should not be input.
11	a small parameter used to check on ill conditioning while solving for superposition constants. Default 1.E-20.
12	convergence test parameter. Default 1.E-8.
13	parameter used in checking for nearly null initial values. Default 1.E-3.

Boundary Value Information

For each boundary condition imposed, a record consisting of five fields is read. The first two fields are integer values, the next two fields are real values, and the last field is another integer value. The format used is

FORMAT (2I5,2G15.7,15)

<u>FIELD</u>	<u>DEFINITION</u>
1	an identifying integer for the boundary condition--these values should range from one through the number of boundary conditions used, with no repetition--they will later be arranged in order according to the ascending values of the independent variable at which the boundary condition occurs.
2	the element of the state variable vector on which the condition is imposed. See Appendix D for <u>general</u> linear and nonlinear boundary conditions.
3	the value of the independent variable at which the condition is imposed.
4	the numerical value of the boundary value.
5	a flag indicating whether the boundary condition is to be met in an exact sense or a best-fit sense-- = 0 implies exact. > 0 implies least-square.

After including one such record for each boundary condition in this group of data, a blank record should again be used to terminate input.

Initial Conditions and Related Data

QUASI requires that initial conditions, either exact or estimated, for each element of the state variable vector be available at the beginning of a solution. It is often the case that some boundary conditions are specified at an initial value of the independent variable, in which case they automatically are placed in the initial condition vector. For each element of the state variable vector for which this does not occur, an estimate of the initial condition should be input at this time. See input of integer parameters, 10th element and SKIP, Appendix B of Reference 1. Each initial condition to be input is included on one record consisting of two integer fields followed by four real fields read according to:

FORMAT (15,G15.7, 3G10.3)

<u>FIELD</u>	<u>DEFINITION</u>
1	integer indicating the element of the state variable vector.
2	= 0 implies an unknown initial condition without bounds (see fields 5, 6) -1 implies an unknown initial condition with bounds. -1 implies an exact initial condition. If this is the case, the fields, h, 5, and 6 are ignored.

<u>FIELD</u>	<u>DEFINITION</u> (cont'd)
3	the floating-point value of the initial condition. Default value = 1.0.
4	the value of an associated perturbation factor, if different from standard value or zero.
5,6	if one of these parameters is non-zero, the larger of the two values will be used as an upper bound for the initial condition and the other value will be a lower bound and if the second field is null, it is then changed to +1.

A blank record is once again used to terminate input of this group of data. This concludes input of a complete data set. If subsequent data sets are incomplete, i.e., with one or more of the four data groups empty, simply include a blank record as a terminator for the empty set and continue as before.

2. Control and Program Cards - (begin Col. 1)

```
!JOB QUASI
!FORTRAN
```

(Source Cards - See Appendix A)

```
!EOD
```

```
:LOAD
:$RDT 256,,G0
:$MP
:END
:SEQ
```

(Input Data)

```
!EOD
```

F. DESCRIPTION OF OUTPUT

Printer Output - The iteration number and solution are given for each boundary value. See Appendix A for sample output.

G. INTERNAL CHECKS AND EXITS

Program exits when input conditions for convergence are met.

H. INDEPENDENT SUBROUTINES

None

I. SYSTEM SUBROUTINES

No special subroutines.

J. COMPLETION OR FINAL CHECKOUT DATE - 4/9/73

Source listing and sample cases are given in Appendix A. The first sample problem is a duplication of the first sample problem discussed in Reference 1. In this problem the boundary conditions are nonlinear and are fitted in a least square sense. The programming of the nonlinear boundary condition equation is done in subroutine NLBC. The second example problem solves the same system of equations appearing in subroutine RHS, but linear boundary conditions are used and the subroutine NLBC is ignored. In the second example problem, the linear boundary conditions are also fitted in the least square sense.

REFERENCES

1. QUASI - Solution of Multipoint Boundary Value Problems of Quasilinear Differential Equations - Bart Childs, et al. University of Houston RE7-69, September 1969.

APPENDIX A

SOURCE LISTING

AND

SAMPLE CASES

```

1 ****
2 **** QUASI ****
3 ****
4 ****
5 C
6 . INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
7 . REAL RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
8 . COMMON IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
9 . . DELT, SPTRB, PNORM, TSTART, TSTOP,
10 . . DET, SMALL, ZERO, DETT, TRACE,
11 . . DZERO, C0NV, DPTRB, DTTEMP, DN1,
12 . 3H,RN1,RN2,T,
13 . 4TAVG,TL,TN,TBM,T,TEM,TEMP,TTEM,TBV( 21),BV( 20),
14 . 5 UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
15 . 5 DIC(20),YPTRB(20),DELTP,DELM, TNORM,SNORM,ANORM,TBVK,DOT,
16 . 1 IBUT, LIN, IQBVS, LITER, NORMRD,
17 . 1 NBV, NEQ, NCN, NWRITE, SKIP,
18 . 1 ITRACE, LIMIT, IVARY, IAF(2),
19 . INVECT,IXTRA,
20 . 1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
21 . 2NRSD,NRYD,I,II,ICOUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
22 . 3 J,JJ,JQ,JSUB,K,KK,KOUNT,KOUT,KQ,KTEM,MITER,NBVM,NCOL,NRANKC,
23 . 4 NR8WS,QBV(20),XACTBV(21),XACTIC(20),IQBV(20),NR,IGO,NE,NI
24 . EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IBUT,IBIG),(DELT,RBIG)
25 ****WARNING, CHECK COMPILER FOR THIS OPTION****
26 ****INPUT INTEGER PARAMETERS****
27 ****WARNING, CHECK COMPILER FOR THIS OPTION****
28 . WRITE(102,15)
29 . WRITE(6,15)
30 . 15 FORMAT(1' MINI-QUASI MODEL'/
31 . * 1 REFER TO GE-AGS USER GUIDE TIR 741-MED-30XX'//)
32 . CALL INIT
33 . 1000 CONTINUE
34 . CALL READIT
35 . CALL SORTBV
36 . CALL NTLIZE
37 . CALL ECHOIN
38 . 5 CONTINUE
39 . CALL ESTABL
40 . CALL NGRATE
41 . IVARY=4
42 . 7 CONTINUE
43 . LIMIT=4
44 . CALL BNETEN
45 . GO TO (17,18,19),IVARY
46 . 17 CONTINUE
47 . CALL WRITES
48 . 20 GO TO (7,18),IGO
49 . 18 CONTINUE
50 . CALL STORES
51 . IF (K=NBV)7,7,19
52 . 19 CONTINUE
53 . IF (ITER=MITER)25,1000,1000
54 . 25 CONTINUE
55 . LIMIT=1
56 . 11 CONTINUE
57 . CALL WRITES
58 . GO TO (12,5,1000),LIMIT

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59      12 CONTINUE
60          DETT = DET
61          CALL GJRWLS
62          LIMIT = 2
63          IF (IPUNT=2)13,11,13
64      13 CONTINUE
65          CALL NEWIC
66          IF (J) 14,11,11
67      14 CONTINUE
68          CALL MODIFY
69          GO TO 13
70      END
71      SUBROUTINE INIT
72      C
73          INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
74          REAL RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
75          COMMON          IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
76          1               DELT, SPTRB, PNORM, TSTART, TSTOP,
77          1               DET, SMALL, ZERO, DETT, TRACE,
78          2               DZERO, C0NV, DPTRB, DTEMP, DN1,
79          3H,RN1,RN2,T,
80          4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
81          5 UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
82          5 DIC(20),YPTRB(20),DELTp,DELM, TNORM, SNORM, ANORM, TBVK, DOT,
83          1               IBUT, LIN, IQBVS, LITER, NORMRD,
84          1               NBV, NEQ, NCN, NWRITE, SKIP,
85          1               ITRACE, LIMIT, IVARY, IAF(2),
86          1NECT,IXTRA,
87          1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
88          2NRSD,NRYD,I,II,ICBUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
89          3 J,JJ,JQ,JSUB,K,KK,KBUNT,KBUT,KR,KTEM,MITER,NBVM,NCOL,NRANKC,
90          4 NR0WS,QBV(20),XACTBV(21),XACTIC(20),IQBV(20),NR,IG0,NE,NI
91          EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IBUT,IBIG),(DELT,RBIG)
92          DATA IDUM, IDUN// 1,1BV1/
93          D0 10 M = 1,135
94      10 IBIG(M)=0
95          RBIG(1)=1.E-1
96          D0 20 I =2,204
97      20 RBIG(I)=0.
98          D0 30 I = 1,20
99      30 IIC(I)=.1E1
100          NRSD = 21
101          NRCD = 21
102          NRYD = 20
103          LITER=5
104          DET=.1E1
105          SPTRB=.12E1
106          SMALL=.1E-9
107          ZERO=.5.E-6
108          DZERO=.1.E-20
109          DPTRB = 1.E-3
110          C0NV = 1.E-8
111          NWRITE=5
112          IAF(1)=IDUM
113          IAF(2)=IDUN
114          RETURN
115          END
116      SUBROUTINE READIT
117      C

```

```

118      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTRV
119      REAL          RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
120      COMMON         IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
121      1              DELT, SPTRB, PNORM, TSTART, TSTOP,
122      1              DET,  SMALL, ZERO, DETT, TRACE,
123      2              DZERO, C0NV, DPTRB, DTEMP, DN,
124      3H,RN1,RN2,T,
125      4TAVG,TL,TN,TBMT,TEM,TEMP,TITEM,TBV( 21),BV( 20),
126      5 UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
127      5 DIC(20),YPTRB(20),DELT,DELM, TNORM, SNORM, ANORM, TBVK, D0T,
128      1.             IBUT, LIN, IQBVS, LITER, NORMRD,
129      1.             NBV,  NEQ, NCN, NWRITE, SKIP,
130      1.             ITRACE, LIMIT, IVARY, IAF(2),
131      1NVECT,IXTRA,
132      1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
133      2NRSD,NRYD,I,II,ICBUNT,JN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
134      3 J,JJ,JQ,JSUB,K,KK,KOUNT,KAUT,KQ,KTEM,MITER,NBVM,NCBL,NRANKC,
135      4 NR0WS,QBV(20),XACTBV(21),XACTIC(20),I0BV(20),NR,IG0,NE,NI
136      EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IBUT,IBIG),(DELT,RBIG)
137      WRITE (6,312)
138      1 READ(5,300)IN1,IN2
139      IF(IN1)230,5,7
140      5 WRITE(6,302)
141      GO TO 11
142      7 WRITE(6,301)IN1,IN2
143      IBIG(IN1)=IN2
144      GO TO 1
145      C****INPUT REAL PARAMETERS****
146      11 READ(5,305) IN1,RN1
147      IF(IN1)15,15,17
148      15 WRITE(6,302)
149      GO TO 20
150      17 WRITE(6,306)IN1,RN1
151      IM100=IN1-100
152      IF(IM100)18,18,19
153      18 RBIG(IN1)=RN1
154      GO TO 11
155      19 AUX(IM100)=RN1
156      GO TO 11
157      C****INPUT BOUNDARY VALUE INFORMATION****
158      20      IQBVM = IQBVS
159      21 READ(5,300) I,IN1,RN1,RN2,IN2
160      IF(I)901,901,905
161      901 WRITE(6,302)
162      GO TO 31
163      905 WRITE(6,301)I,IN1,RN1,RN2,IN2
164      IF(IN1)906,907,907
165      906 IF(IN1+100)907,907,908
166      907 QBV(I)=IN1
167      908 TBV(I)=RN1
168      BV(I)=RN2
169      XACTBV(I)=IN2
170      IF(IN1)909,21,21
171      909 IF(IN1+100)910,910,22
172      910 IF(QBV(I))911,22,22
173      911 IN2=QBV(I)/100
174      IF(IN1-(QBV(I)-IN2*100))22,912,912
175      912 IQBVS=-IN2
176      22 IF(IN1+100) 851,851,850

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177      850 QBV(I) = -(IQBVS+1)*100-IN1
178      851 IN1 = -QBV(I)+(QBV(I)/100)*100
179      IF(IN1>13,21,913
180      913 DO 23 I=1,IN1
181      IQBVS = IQBVS + 1
182      READ (5,305) IQBV(IQBVS),CQBV(IQBVS)
183      IF(IQBV(IQBVS)>23,914,23
184      914 IQBV(IQBVS)=1
185      23 WRITE (6,306) IQBV(IQBVS),CQBV(IQBVS)
186      IF(IQBVS>IQBVM)24,21,25
187      24 IQBVS=IQBVM
188      GO TO 21
189      25 IQBVM=IQBVS
190      GO TO 21
191      C****INPUT INITIAL CONDITIONS AND RELATED DATA****
192      31 READ (5,310) IN1,IN2,DN1,RN1,RN2,RN3
193      IF(IN1>32,32,915
194      32 WRITE(6,302)
195      GO TO 34
196      915 WRITE(6,311)IN1,IN2,DN1,RN1,RN2,RN3
197      IIC(IN1) = DN1
198      PTRB (IN1) = RN1
199      XACTIC (IN1) = IN2
200      IF(ABS(RN2)=DZERO)916,916,917
201      916 IF(ABS(RN3)=DZERO)31,917,917
202      917 IF(RN2=RN3)918,918,33
203      918 TEMP=RN2
204      RN3 = TEMP
205      33      UPPER(IN1) = RN2
206      LOWER(IN1) = RN3
207      XACTIC (IN1) = 1
208      GO TO 31
209      34 RETURN
210      230 STOP
211      300 FORMAT (2I5,2E15.7,I5)
212      301 FORMAT (16H INPUT DATA CARD,2I5,2E15.7,I5)
213      302 FORMAT (15X,16H BLANK DATA CARD,//)
214      305 FORMAT (I5,E15.7)
215      306 FORMAT (16H INPUT DATA CARD, I5, E15.7)
216      310 FORMAT (2I5,E15.7,3E10.3)
217      311 FORMAT (16H INPUT DATA CARD,2I5,4E15.7)
218      312 FORMAT(1H1)
219      END
220      SUBROUTINE SORTBV
221      C
222      C****SORT BOUNDARY VALUES****
223      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
224      REAL      RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
225      COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
226      1          DELT,      SPTRB,      PNORM,      TSTART,      TSTOP,
227      1          DET,       SMALL,      ZERO,       DETT,       TRACE,
228      2          DZERO,      C0NV,      DPTRB,      DTEMP,      DN1,
229      3H,RN1,RN2,T,
230      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
231      5 UPPER(20),LOWER(20),PRTB(20),AUX(10),CQBV(20),
232      5 DIC(20),YPTRB(20),DELTp,DELTm,TNORM,SNORM,ANORM,TBVK,D0T,
233      1          I0UT,      LIN,      IQBVS,      LITER,      NORMRD,
234      1          NBV,       NEQ,      NCN,      NWRITE,      SKIP,
235      1          ITRACE,    LIMIT,    IVARY,      IAF(2),

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```

236    INVECT,IXTRA,
237    1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
238    2NRSD,NRYD,I,II,ICOUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
239    3 J,JJ,JQ,JSUB,K,KK,KOUNT,KBUT,KQ,KTEM,MITER,NBVM,NCOL,NRANKC,
240    4 NRWS,QBV(20),XACTBV(21),XACTIC(20),IQBV(20),NR,IGB,NE,NI
241    EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IBUT,IBIG),(DELT,RBIG)
242    34 IF (NBV)42,42,919
243    919 IF(NBV=1)41,41,920
244    920 IS=1
245    NBVM=NBV-1
246    35 DO 40 I=IS,NBVM
247    IF(TBV(I+1)=TBV(I))37,40,40
248    37 TEMP=TBV(I)
249    TBV(I)=TBV(I+1)
250    TBV(I+1)=TEMP
251    TEMP=BV(I)
252    BV(I)=BV(I+1)
253    BV(I+1)=TEMP
254    ITEMP=QBV(1)
255    QBV(I)=QBV(I+1)
256    QBV(I+1)=ITEMP
257    ITEMP=XACTBV(I)
258    XACTBV(I)=XACTBV(I+1)
259    XACTBV(I+1)=ITEMP
260    IF(I-1)35,35,38
261    38 IS= I-1
262    GO TO 35
263    40 CONTINUE
264    41 IF(TSTOP-TBV(NBV))921,921,922
265    921 TSTOP=TBV(NBV)
266    922 IF(TSTART-TBV(1))42,42,923
267    923 TSTART=TBV(1)
268    42 CONTINUE
269    RETURN
270    END

```

 SUBROUTINE NTLIZE

C

```

273    INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
274    REAL RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
275    COMMON   IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
276    1        DELT, SPTRB, PNORM, TSTART, TSTOP,
277    1        DET,  SMALL, ZERB, DETT, TRACE,
278    2        DZERB, C0NV, DPTRB, DTEMP, DN1,
279    3H,RN1,RN2,T,
280    4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
281    5UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
282    5DIC(20),YPTRB(20),DELTP,DELM, TNORM, SNORM, ANORM, TBVK, DOT,
283    1        IBUT, LIN, IQBVS, LITER, NORMRD,
284    1        NBV,  NEQ, NCN, NWRITE, SKIP,
285    1        ITRACE, LIMIT, IVARY, IAF(2),
286    INVECT,IXTRA,
287    1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
288    2NRSD,NRYD,I,II,ICOUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
289    3 J,JJ,JQ,JSUB,K,KK,KOUNT,KBUT,KQ,KTEM,MITER,NBVM,NCOL,NRANKC,
290    4 NRWS,QBV(20),XACTBV(21),XACTIC(20),IQBV(20),NR,IGB,NE,NI
291    EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IBUT,IBIG),(DELT,RBIG)
292    DELTP=1.1 *DELT
293    DELTM=0.9 *DELT
294    C***INITIALIZE IC,DIC, AND XACTIC***
```

```

295      NVECT=NEQ+NCN
296      46 DO 50 I=1,NVECT
297      DIC(I) = 0.
298      IC(I)=IIC(I)
299      IF(NBV)47,47,49
300      47 IF(XACTIC(I))49,48,48
301      48 XACTIC(I)=-1
302      49 IF(XACTIC(I)+1)924,50,50
303      924 XACTIC(I) = XACTIC(I)+4
304      50 CONTINUE
305      TNORM = 1.
306      SNORM = PNORM
307      NROWS=NBV+1
308      IF (NBV)61,61,52
309      52 DO 60 I=1,NVECT
310      IF(ABS(TBV(I)-TSTART))55,55,61
311      55 IQ=QBV(I)
312      IF(IQ)57,57,56
313      56 IC(IQ)=BV(I)
314      57 IF(XACTBV(I))58,58,60
315      58 IF(IQ)60,60,59
316      59 NROWS = NROWS -1
317      XACTBV(I)=-1
318      XACTIC(IQ) = XACTIC(IQ) - 4
319      60 CONTINUE
320      61 KOUNT=0
321      DO 70 I=1,NVECT
322      IF(XACTIC(I))62,63,63
323      62 KOUNT=KOUNT+1
324      GO TO 70
325      63 IF(ABS(PTRB(I))=DZERO)64,70,70
326      64 PTRB(I)=SPTRB
327      70 CONTINUE
328      ITER=0
329      MITER=LITER
330      IF(KOUNT=NVECT)926,925,925
331      925 MITER=1
332      926 NRANKC=NVECT-KOUNT+1
333      NCOL=NRANKC+1
334      RETURN
335      END
336      SUBROUTINE ECHOIN
337      C
338      C      ECHOIN
339      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
340      REAL      RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
341      COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
342      1          DELT,      SPTRB,      PNORM,      TSTART,      TSTOP,
343      1          DET,       SMALL,      ZERO,       DETT,       TRACE,
344      2          DZERO,     CINV,      DPTRB,     DTEMP,      DN1,
345      3H,RN1,RN2,T,
346      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
347      5 UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
348      5 DIC(20),YPTRB(20),DELTP,DELM, TNORM,SNORM,ANORM,TBVK,DBT,
349      1          IBUTS,     LIN,      IQBVS,      LITER,      NORMRD,
350      1          NBV,      NEQ,      NCN,      NWRITE,      SKIP,
351      1          ITRACE,    LIMIT,     IVARY,      IAF(2),
352      INVECT,IXTRA,
353      1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,

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```

854      2NRSD, NRYD, I, II, ICOUNT, IN1, IN2, INTKEY, IPUNT, IQ, IS, ISUB, ITEMP, ITER,
855      3 J, JJ, JQ, JSUB, K, KK, KOUNT, KOUT, KQ, KTEM, MITER, NBVM, NCOL, NRANKC,
856      4 NRWS, QBV(20), XACTBV(21), XACTIC(20), IQBV(20), NR, IGB, NE, NI
857      EQUIVALENCE (YVEC, Y), (S, SVEC), (YVEC, C), (IBUT, IBIG), (DELT, RBIG)
858      C
359      C****ECHO THE INPUT DATA****
360      WRITE(6,350)
361      IF(NBV)73,73,927
362      927 DO 72 I=1,NBV
363      WRITE (6,400) I,TBV(I),BV(I),QBV(I),XACTBV(I)
364      IF(QBV(I))928,72,72
365      928      J= -QBV(I)/100
366      K = -QBV(I) - J*100 - 1 + J
367      WRITE (6,440) (CQBV(M),IQBV(M),M,M=J,K)
368      72 CONTINUE
369      73 WRITE(6,450)
370      DO 74 I=1,NVECT
371      74 WRITE (6,500) I,IC(I),XACTIC(I),PTRB(I),UPPER(I),LOWER(I)
372      WRITE(6,307)IBUT,LIN,IQBV, LITER,NORMRD,NBV,NEQ,NCN,NWRITE,SKIP,
373      1DELT,SPTRB,PNORM,TSTART,TSTOP,NRANKC
374      360 FORMAT (4H AUX,/(1X,8E15.7))
375      WRITE (6,360) (AUX(I),I=1,10)
376      RETURN
377      307 FORMAT (//10X,4HIBUT,I6,10X,3HLIN,I7,5HIQBVS,I5,10X,5HLITER,I5,10X
378      1,6HNORMRD,I4//12X,3HNBV,I7,10X,3HNEQ,I7,10X,3HNCN,I7,10X,6HNWRITE,
379      2I4,10X,4HSKIP,I6//1X,4HDELT,E16.6,5X,5HSPTRB,E15.6,5X,5HPNORM,E15.
380      36,5X,6HTSTART,E14.6,5X,5HTSTOP,E15.6///10H GENERATED/10X,6HNANKC,
381      4I4)
382      350 FORMAT(1X//16X,3HTBV,17X,3HB-V,13X,3HQBVS,4X,5HXCTBV)
383      400 FORMAT (1X,I5,2(5X,E15.7),2I8)
384      440 FORMAT (30X,E15.7,3H*Y(,I4,1H),20X,I5)
385      450 FORMAT(1X//3X,3HY(,8X,2HIC,13X,5HXCTIC,10X,4HPTRB,15X,
386      15HUPPER,15X,5HLWER)
387      500 FORMAT(4X,I2,5X,E15.7,5X,I3,4(5X,E15.7))
388      END
389      SUBROUTINE ESTABL
390      C
391      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTRV
392      REAL RBIG(204),LWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
393      COMMON IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
394      1 DELT, SPTRB, PNORM, TSTART, TSTOP,
395      1 DET, SMALL, ZERO, DETT, TRACE,
396      2 DZERO, C0NV, DPTRB, DTEMP, DN1,
397      3H,RN1,RN2,T,
398      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
399      5 UPPER(20),LWER(20),PTRB(20),AUX(10),CQBV(20),
400      5 DIC(20),YPTRB(20),DELT,DELM, TNORM, SNORM, ANORM, TBVK, DOT,
401      1 IBUT, LIN, IQBV, LITER, NORMRD,
402      1 NBV, NEQ, NCN, NWRITE, SKIP,
403      1 ITRACE, LIMIT, IVARY, IAF(2),
404      1NVECT,IXTRA,
405      1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
406      2NRSD, NRYD, I, II, ICOUNT, IN1, IN2, INTKEY, IPUNT, IQ, IS, ISUB, ITEMP, ITER,
407      3 J, JJ, JQ, JSUB, K, KK, KOUNT, KOUT, KQ, KTEM, MITER, NBVM, NCOL, NRANKC,
408      4 NRWS, QBV(20), XACTBV(21), XACTIC(20), IQBV(20), NR, IGB, NE, NI
409      EQUIVALENCE (YVEC, Y), (S, SVEC), (YVEC, C), (IBUT, IBIG), (DELT, RBIG)
410      C****ESTABLISH INITIAL CONDITIONS IN YVEC****
411      79 ITER=ITER+1
412      TRACE = 0.

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413 JSUB==NRYD
414 JQ = 0
415 D0 100 J=1,NRANKC
416 JSUB=JSUB+NRYD
417 D0 80 I=1,NVECT
418 IZ = JSUB + I
419 80 YVEC( IZ)=IC(I)
420 IF(JSUB)82,100,82
421 82 IS=JQ+J-1
422 D0 90 I=IS,NVECT
423 IFIXACTIC(I))90,92,92
424 90 JQ = JQ + 1
425 92 JJ = J - 1 + JQ
426 IZ=JSUB+JJ
427 YVEC(IZ)=YVEC(IZ)*PTRB(JJ)
428 IF(ABS(YVEC(IZ)=DPTRB))93,94,94
429 93 YVEC(IZ)=1.
430 94 YPTRB(JJ)=YVEC(IZ)
431 100 CONTINUE
432 RETURN
433 END
434
435 C
436 SUBROUTINE NGRATE
437
438      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
439      REAL      RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
440      COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
441      1          DELT,      SPTRB,      PNORM,      TSTART,      TSTOP,
442      1          DETS,      SMALL,      ZERO,      DETT,      TRACE,
443      2          DZERO,      C0NV,      DPTRB,      DTEMP,      DN1,
444      3H,RN1,RN2,T,
445      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
446      5 UPPER(20),LOWER(20),PRTB(20),AUX(10),CQBV(20),
447      5 DIC(20),YPTRB(20),DELT,DELM,TNORM,SNORM,ANORM,TBVK,DT,
448      1          IBUT,      LIN,      IQRVS,      LITER,      NORMRD,
449      1          NBV,      NEQ,      NCN,      NWRITE,      SKIP,
450      1          ITRACE,      LIMIT,      IVARY,      IAF(2),
451      1NVECT,IXTRA,
452      1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
453      2NRSD,NRYD,I,II,ICOUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
454      3 J,JQ,JSUB,K,KK,KOUNT,KOUT,KQ,KTEM,MITER,NBVM,NCOL,NRANKC,
455      4 NRWS,QBV(20),XACTBV(21),XACTIC(20),IQBV(20),NR,IG0,NE,NI
456      EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IBUT,IBIG),(DELT,RBIG)
457      ****INTEGRATION*****
458      102 KOUT=0
459      . IF(IBUT=2)104,104,103
460      104 IF(ITER=MITER)929,103,103
461      103 KOUT=1
462      929 IF(10UT=4)931,930,930
463      930 WRITE(6,630)
464      931 NI=NRWS+1
465      NE=1
466      JSUB==NRSD
467      D0 105 I=1,NCOL
468      JSUB=JSUB+NRSD
469      105 SVEC(JSUB+1)=1.
470      TL=TSTART
471      ICOUNT=NWRITE
472      IF(ABS(TBV(1)-TSTART)=ZERO)106,106,107
473      106 ICOUNT=0

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472      107 IF(ITER=MITER)936,935,935
473      935 WRITE(6,590)
474      936 WRITE(6,600)ITER,MITER
475          INTKEY=0
476          IN1 = NRANKC
477      932 IF(MITER=ITER)933,933,934
478      933 IN1=1
479      934 K=1
480          TBVK = TBV(K)
481      110 TEM=0.
482          RETURN
483      600 FORMAT (20X,4HITER,I4,4H 0F,I4,/,10X,4HTIME,14X,8HSOLUTION)
484      630 FORMAT(1X/10X,39HREPEATED TIMES ARE PARTICULAR SOLUTIONS,/)
485      590 FORMAT(1H1)
486          END
487          SUBROUTINE STORES
488      C
489      C          STORES
490          INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
491          REAL      RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
492          COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
493          1          DELT, SPTRB, PNORM, TSTART, TSTOP,
494          1          DET,  SMALL, ZERO, DETT, TRACE,
495          2          DZERO, C0NV, DPTRB, DTEMP, DN1,
496          3H,RN1,RN2,T,
497          4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
498          5 UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
499          5 DIC(20),YPTRB(20),DELTP,DELM, TNORM, SNORM, ANORM, TBVK, DOT,
500          1          IBUT, LIN, IQRVS, LITER, NORMRD,
501          1          NBV,  NEO, NCN, NWRITE, SKIP,
502          1          ITRACE, LIMIT, IVARY, IAF(2),
503          1NVECT,IXTRA,
504          1JXTRA,KXTRA,NBUT,NL,NSPACE,NRCD,
505          2NRSD,NRYD,I,II,ICBUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
506          3 J,JJ,JQ,JSUB,K,KK,KBUNT,KAUT,KQ,KTEM,MITER,NBVM,NC0L,NRANKC,
507          4 NROWS,QBV(20),XACTBV(21),XACTIC(20),IBBV(20),NR,IGO,NE,NI
508          EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IBUT,IBIG),(DELT,RBIG)
509          134 IF (XACTBV(K)) 152,135,135
510          135 IQ = QBV(K)
511          IF(XACTBV(K))139,138,139
512          139 NI=NI-1
513          NR=NI
514          GO TO 140
515          138 NE=NE+1
516          NR=NE
517          140 ISUB==NRYD
518          JSUB==NRSD
519          IF (IQ)143,143,144
520          143 J= -IQ/100
521          IS = J - (IQ + J*100) - 1
522          144 DO 150 I=1,NRANKC
523          ISUB = ISUB + NRYD
524          JSUB = JSUB + NRSD
525          IF(IQ)145,145,147
526          147 IZ = IQ + ISUB
527          DOT = YVEC(IZ)
528          GO TO 148
529          145 DOT = 0.
530          IF (IS-J)149,950,950

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531      950      D0 146 M=J,IS
532          JJ = IQBV(M)
533      IZ = JJ + ISUB
534      146      DOT = DOT + YVEC(IZ)*CQBV(M)
535      148      IZ = NR + JSUB
536          SVEC(IZ) = DOT
537      149      IF (I=NRANKC)150,951,150
538      951      IZ = NR+NRSD+JSUB
539          SVEC(IZ) = BV(K)
540      150      CONTINUE
541      151      IF(IQ)952,952,152
542      952      IF(IS=J)953,152,152
543      953      CONTINUE
544          CALL NLBC
545      152      K = K + 1
546          IF(K=NBV)154,154,153
547      153      IF(IITER=MITER)170,154,154
548      154      IF(K=NBV)954,954,955
549      954      TBVK=TBV(K)
550          GO TO 956
551      955      TBVK=TSTOP+2.*DELT
552      956      IF(ABS(TBVK-TBV(K-1)))134,134,957
553      957      TEM=TEM+TBMT
554          TEM=TEM+TBMT
555          TTEM=TL+DELT-TEM
556          IF(TEM=DELT)155,958,958
557      958      TTEM=TL+2.*DELT-TEM
558          KTEM=KTEM+1
559          IF(KTEM=1)960,959,960
560      959      ICOUNT=ICOUNT+1
561      960      IF(ICOUNT=NWRITE)155,961,155
562      961      ICOUNT=0
563      155      INTKEY=0
564          IF(ABS(TTEM-TBVK))110,110,157
565      157      IF(TTEM=TBVK)158,158,112
566      158      H=TTEM-TL
567          I=-1
568      110      RETURN
569      170      I = 0
570          RETURN
571      112      J = 0
572          RETURN
573      END
574      SUBROUTINE NLBC
575      C
576          REAL          LF,DY(20),U(20)
577          COMMON   F1C(40),P(20,21),C(80),LF(20),S(21,22),
578          1          RD1(9),TRACE,RD2(5),H,RD3(2),T,RD4(7),TBV(21),BV(80),
579          2          AUX(10),CQ(67),
580          3          ID1(16),IPART,JSUB, ID2(2),NL, ID3(29),NRANKC, ID4(62),IQ(24)
581          EQUIVALENCE (TL,RD4(2)),(J, ID3(17)),(K, ID3(21)),(NR,IQ(21))
582          EQUIVALENCE (LF,DY),(P,U)
583          D0 80 ICL = 1, NRANKC
584          ASM = 0.
585          D0 79 IDX = 1,4
586          IZ=5-IDX
587          79 ASM=ASM=U(IZ)*P(IDX,ICL)
588          80  S(NR,ICL) = ASM
589          S(NR, NRANKC+1)=BV(K)= SIN(U(5)*TL)=U(1)*U(4)-U(2)*U(3)

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590      RETURN
591      END
592      SUBROUTINE NEWIC
593      C
594      C      NEWIC
595      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
596      REAL      RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
597      COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
598      1          DELT,      SPTRB,      PNORM,      TSTART,      TSTOP,
599      1          DET,       SMALL,      ZERO,       DETT,       TRACE,
600      2          DZERO,     CONV,       DPTRB,      DTEMP,      DN1,
601      3H,RN1,RN2,T,
602      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
603      5 UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
604      5 DIC(20),YPTRB(20),DELTP,DELM, TNORM, SNORM, ANORM, TBVK, DOT,
605      1          IOUT,      LIN,       IQBVS,      LITER,      NORMRD,
606      1          NBV,       NEQ,      NCN,       NWRITE,      SKIP,
607      1          ITRACE,    LIMIT,     IVARY,      IAF(2),
608      1NECT,IXTRA,
609      1JXTRA,KXTRA,NOUT,NL,NSPACE,NRCD,
610      2NRSD,NRYD,I,II,ICOUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
611      3 J,JJ,JQ,JSUB,K,KK,KOUNT,KAUT,KQ,KTEM,MITER,NBVM,NCOL,NRANKC,
612      4 NRWS,QBV(20),XACTBV(21),XACTIC(20),IQBV(20),NR,IG0,NE,NI
613      EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IOUT,IBIG),(DELT,RBIG)
614      ****CALCULATE NEW INITIAL CONDITIONS****
615      IF (J) 970,188,188
616      188 KQ=0
617      ANORM = 0.
618      DOT = 0.
619      JSUB=NRANKC*NRSD
620      DO 210 J=1,NVEC
621      IF(XACTIC(J))190,195,195
622      190 KQ=KQ+1
623      GO TO 210
624      195 JJ=J-KQ+1
625      ****CALCULATE NEW J-TH ELEMENT OF INITIAL CONDITION VECTOR****
626      IZ = JJ + JSUB
627      DTEMP= SVEC(IZ)
628      DTEMP = YPTRB(J)*DTEMP + IC(J)*(1. - DTEMP)
629      TDIC = DTEMP - IC(J)
630      IF(ABS(PNORM)=ZERO)205,198,198
631      198  DTEMP=DIC(J)*0.5
632      IF(TDIC*DIC(J))199,205,205
633      199  IF (ABS(TDIC)=ABS(DTEMP)) 205,205,200
634      200  TDIC=-DTEMP
635      205  DOT = DOT + TDIC*DIC(J)
636      ANORM = ANORM + TDIC**2
637      DIC(J) = TDIC
638      210 CONTINUE
639      ANORM = SQRT(ANORM)
640      DOT = DOT/(ANORM*TNORM)
641      212 IF(PNORM)970,970,213
642      213 CONTINUE
643      J = -1
644      RETURN
645      970 IF(ANORM=SNORM)971,963,963
646      971 IF(NORMRD)963,963,962
647      962 SNORM=ANORM
648      963 TNORM=ANORM

```

```

649      DO 215 J=1,NVECT
650      IF(XACTIC(J)>215,964,964
651      IC(J)=IC(J)+DIC(J)
652      IF(XACTIC(J)=1)214,965,965
653      IF(IC(J)=UPPER(J))967,967,966
654      IC(J)=UPPER(J)
655      IF(IC(J)=LOWER(J))968,214,214
656      IC(J)=LOWER(J)
657      214 IF(SKIP)215,969,215
658      IIC(J)=IC(J)
659      215 CONTINUE
660      DO 220 I=2,NRANKC
661      IZ=I+JSUB
662      IF(ABS(SVEC(IZ))=CONV)220,216,216
663      216 IF(IITER=LITER)79,220,220
664      220 CONTINUE
665      MITER=ITER+1
666      79 RETURN
667      END
668      SUBROUTINE MBDIFY
669      C
670      INTEGER QBV,XACTBV,SKIP,IBIG(135)
671      REAL      RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
672      COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
673      1          DELT, SPTRB, PNORM, TSTART, TSTOP,
674      1          DET,  SMALL, ZERO, DETT, TRACE,
675      2          DZERO, CONV, DPTRB, DTEMP, DN1,
676      3H,RN1,RN2,T,
677      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
678      5 UPPER(20),LOWER(20),PTRB(20),AUX(10),CQBV(20),
679      5 DIC(20),YPTRB(20),DELTP,DELTMS,TNORM,SNORM,ANORM,TBVK,DOT,
680      1          IOUT, LIN, IQBVS, LITER, NORMRD,
681      1          NBV, NEQ, NCN, NWRITE, SKIP,
682      1          ITRACE, LIMIT, IVARY, IAF(2),
683      1NVECT,IXTRA,
684      1JXTRA,KXTRA,NOUT,NL,NSPACE,NRCD,
685      2NRSD,NRYD,I,II,ICOUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
686      3 J,JJ,JQ,JSUB,K,KK,KOUNT,KOUT,KQ,KTEM,MITER,NBVM,NCOL,NRANKC,
687      4 NROWS,QBV(20),XACTBV(20), KIC(21),IQBV(20),NR,IG0,NE,NI
688      EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IOUT,IBIG),(DELT,RBIG)
689      IF (ANORM=PNORM)2,4,4
690      2 IF (DOT)4,4,3
691      3 RETURN
692      4 C0EF=1.
693      IF (ANORM=PNORM)6,6,5
694      5 C0EF = PNORM/ANORM
695      6 ITERM = -PNORM/ANORM - 1.
696      IF(ITEMR+10)7,8,8
697      7 ITERM=-10
698      8 IF(DOT)9,10,10
699      9 C0EF = C0EF*(1.+DOT*10.***ITEM)
700      10 DO 20 I=1,NVECT
701      IF(KIC(I)>20,20,11
702      11 DIC(I) = C0EF*DIC(I)
703      20 CONTINUE
704      ANORM = ANORM*C0EF
705      RETURN
706      END
707      SUBROUTINE GJRWLS

```

```

708      C
709      INTEGER I(21),J(22),JZC(20),IJTV(20)
710      COMMON AD1(40),B(21,22),AD2(58),A(21,22),AD3(8),SET,TRACE,CHECK,AD
711      14(193),IBUT, ID1(21),NRB,NRA, ID2(7),IPUNT, ID3(18),N, NR0WA, ID4(60),
712      2      NEMAX, ID5(24)
713      EQUIVALENCE (AD2(39),IJTV)
714      NTOTAL = N + 1.
715      LSTOP=NEMAX
716      NR0W=NR0WA
717      NEND=NR0WA
718      IF(NR0WA=NTOTAL)20,30,30
719      20 NEND=NTOTAL
720      30 DO 100 L=1,NEND
721      IF(L=NTOTAL)40,40,100
722      40 J(L)=L
723      100 I(L)=L
724      DO 650 K=1,N
725      C=0.0
726      DO 200 L=K,LSTOP
727      IL = I(L)
728      DO 200 M = K, N
729      JM=J(M)
730      ABSA=ABS(A(IL,JM))
731      IF(ABSA=C)200,200,190
732      190 KL = L
733      KM = M
734      C = ABSA
735      200 CONTINUE
736      KI = I(KL)
737      KJ = J(KM)
738      I(KL) = I(K)
739      I(K) = KI
740      J(KM) = J(K)
741      J(K) = KJ
742      AKK = A(KI,KJ)
743      A(KI,KJ)=1.
744      DET = DET*AKK
745      IF(NEMAX=N)260,260,250
746      250 IF(K=N)260,1400,1400
747      260 IF(C=CHECK)345,345,350
748      345 CONTINUE
749      IPUNT = 2
750      RETURN
751      350 AD2(K+18)=AKK
752      IJTV(K)= 100*KI+KJ
753      370 AKK=1.0/AKK
754      KP1=K+1
755      DO 400 M=KP1,NTOTAL
756      JM=J(M)
757      400 A(KI,JM)=AKK*A(KI,JM)
758      DO 600 L=1,NR0W
759      IF(L=K)420,600,420
760      420 IL=I(L)
761      AKK = A(IL,KJ)
762      A(IL,KJ)=0.
763      DO 500 M=KP1,NTOTAL
764      JM= J(M)
765      500 A(IL,JM) = A(IL,JM) - AKK*A(KI,JM)
766      600 CONTINUE

```

```

769      IF(K=NEMAX)650,610,650
768      610 IF(N=K)650,650,620
769      620 DO 621 L = 1,N
770      JZC(L) =0
771      DO 621 M=1,NTOTAL
772      621 B(L,M) = 0.
773      DO 627 L=KP1,N
774      IRAT = J(L)
775      JZC(IRAT) = 1
776      DO 626      M=KP1,NTOTAL
777      JCA = J(M)
778      IF (IRAT=JCA) 622,622,626
779      622 TEMP = 0.
780      DO 623 KR = KP1,NRWA
781      623 TEMP = TEMP + A(KR,IRAT)*A(KR,JCA)
782      B(IRAT,JCA) = TEMP
783      IF (IRAT=JCA) 624,626,626
784      624 IF (JCA=N) 625,625,626
785      625 B(JCA,IRAT) = TEMP
786      626 C0NTINUE
787      627 C0NTINUE
788      IRA = K
789      DO 630 L = 1,N
790      IF (JZC(L)) 628,630,628
791      628 IRA = IRA + 1
792      DO 629 M = KP1,NTOTAL
793      JCA = J(M)
794      629 A(IRA,JCA) = B(L,JCA)
795      630 C0NTINUE
796      LSTOP = N
797      NROW = N
798      650 C0NTINUE
799      DO 1000 K=1,N
800      KI = I(K)
801      KJ = J(K)
802      IF(KI=KJ)660,800,660
803      660 DO 700 M=1,NTOTAL
804      AKK=A(KI,M)
805      A(KI,M) = A(KJ,M)
806      700 A(KJ,M) = AKK
807      800 DO 900 L = K,N
808      IF(I(L)=J(K))900,950,900
809      900 C0NTINUE
810      950 I(L) = I(K)
811      1000 I(K) = L
812      1400 C0NTINUE
813      1450 IPUNT=1
814      RETURN
815      END
816      SUBROUTINE UNETEN
817      C
818      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTBV
819      REAL      RBIG(204),LOWER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
820      COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
821      1          DELT,      SPTRB,      PNORM,      TSTART,      TSTOP,
822      1          DET,       SMALL,      ZERB,       DETT,       TRACE,
823      2          DZERB,      C0NV,      DPTRB,      DTEMP,      DN1,
824      3H,RN1,RN2,T,
825      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),

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826      5 UPPER(20), LOWER(20), PRTB(20), AUX(10), CQBV(20),
827      5 DIC(20), YPTRB(20), DELTP, DELTM, TNORM, SNORM, ANORM, TBVK, DBT,
828      1           IBUT, LIN, IQBVS, LITERS, NORMRD,
829      1           NBV, NEQ, NCN, NWRITE, SKIP,
830      1           ITRACE, LIMIT, IVARY, IAF(2),
831      1 INVECT, IXTRA,
832      1 JXTRA, KXTRA, NBUT, NL, NSPACE, NRCD,
833      2 NRSD, NRYD, I, II, ICOUNT, IN1, IN2, INTKEY, IPUNT, IQ, IS, ISUB, ITEMP, ITER,
834      3 J, JJ, JQ, JSUB, K, KK, KBUNT, KBUT, KQ, KTEM, MITER, NBVM, NCOL, NRANKC,
835      4 NRWS, QBV(20), XACTBV(21), XACTIC(20), IGBV(20), NR, IGO, NE, NI
836      EQUIVALENCE (YVEC, Y), (S, SVEC), (YVEC, C), (IBUT, IBIG), (DELT, RBIG)
837      GO TO (111, 105, 105, 105), IVARY
838      105 IF (J) 106, 112, 106
839      106 IF (I) 118, 110, 110
840      110 TEM = 0.
841      KTEM=0
842      IF (TL-TSTOP) 937, 937, 135
843      937 IF (ICOUNT=NWRITE) 112, 938, 938
844      938 IGO=1
845      109 IF (KBUT=1) 939, 940, 940
846      939 IF (ABS(TL-TSTART)) 940, 940, 941
847      941 GO TO (111, 134), IGO
848      940 NBUT=NEQ
849      IF (ABS(TL-TSTART)) 942, 942, 943
850      942 NBUT=NVECT
851      943 CONTINUE
852      IVARY = 1
853      RETURN
854      111 ICOUNT=0
855      112 TBMT = TBVK = TL
856      IF (TBMT=DELTP) 115, 115, 114
857      115 INTKEY=1
858      H=TBMT
859      GO TO 118
860      114 H=DELT
861      118 T = TL + H
862      CALL DBIT
863      TL=TL+H
864      IF (INTKEY=1) 131, 130, 131
865      131 ICOUNT=ICOUNT+1
866      GO TO 110
867      130 IGO = 2
868      GO TO 109
869      134 IVARY = 2
870      RETURN
871      135 IVARY = 3
872      RETURN
873      END
874      SUBROUTINE DBIT
875      C
876      REAL      YK(20), YP(20), A(3), TN(4), B(3), LF
877      COMMON    DD1( 40), Y( 420), C(80), LF(20), SVEC(462),
878      1           RD1(15), HH, RD2(4), T, RD3(183),
879      2           IBUT, LIN, ID1(4), NEQ, ID2(8), NVECT, IPART, JSUB,
880      3           ID3(2), NL, ID4(3), NRYD, ID5(3), IN1, ID6(108)
881      DATA A/1., 2., 2./
882      IPART=0
883      ISUB=-NRYD
884      IGO=0

```

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885 1 IPART=IPART+1
886  TI=T
887  IF(IPART=IN1)3,3,2
888 2 RETURN
889 3 ISUB=ISUB+NRYD
890  H=HH
891  NL=1
892  IF(IPART=1)101,102,101
893 101 IF(LIN)103,103,102
894 102 NL=0
895 103 IF(IPART=1) 104,104,15
896 104 IF(LIN)105,105,15
897 105 H= HH/2,E0
898 4 IPT = IG0*NRYD
899  D0 5 I = 1,NVECT
900  IZ = IPT + I
901 5 C(IZ) = Y(I)
902  IG0=IG0+1
903  IF(IG0=2)15,15,1
904 15 D0 20 I=1,NVECT
905  IZ = ISUB + I
906  YK(I) = Y(IZ)
907  YP(I) = 0.
908 20 CONTINUE
909  H06 = H/6.
910  B(1) = H/2.
911  B(2)=B(1)
912  B(3)=H
913  TN(1)=TI
914  TN(2)=TI+B(1)
915  TN(3)=TN(2)
916  TN(4)=TI+H
917  JSUB=-1
918  D0 30 J=1,4
919  IF(J=3)106,107,106
920 106 JSUB=JSUB+1
921 107 IPT = JSUB*NRYD+1
922  CALL RHS (YK,C(IPT),C(IPT),TN(J))
923  IF(J=4)25,50,25
924 25 D0 30 I=1,NEQ
925  YP(I)=YP(I)+A(J)*LF(I)
926  IZ = ISUB + I
927 30 YK(I) = Y(IZ) + B(J)*LF(I)
928 50 D0 60 I=1,NEQ
929  IZ=ISUB+I
930 60 Y(IZ) = Y(IZ) + H06*(YP(I)+LF(I))
931  IF(IPART=1)65,65,1
932 65 IF(LIN)68,68,1
933 68 TI=TN(4)
934  G0 T8 4
935  END
936  SUBROUTINE RHS(Y,Y0,Y0,TN)
937  C
938  REAL      Y0(20),Y0(20),LF,DY(20),U(20),Y(20)
939  COMMON    F1C(40),P(20,21),C(80),LF(20),S(21,22),
940 1      RD1(9),TRACE,RD2(5),H,RD3(2),T,RD4(7),TBV(21),BV(80),
941 2      AUX(10),CQ(67),
942 3      ID1(16),IPART,JSUB, ID2(2),NL, ID3(29),NRANKC, ID4(62),ID(24),
943  EQUIVALENCE (LF,DY),(P,U)

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944      NRC = 20
945      IF(NL)45,45,50
946
947      C
948      C      HERE ARE THE NON-LINEAR (OR LINEAR) EQUATIONS
949      C
950      45 CONTINUE
951      DY(1) = Y(2)
952      DY(2) = -Y(1)*Y(4)-Y(2)*Y(3)+SIN(Y(5)*TN)
953      47 RETURN
954      50 CONTINUE
955
956      C
957      C      HERE ARE THE LINEARIZED EQUATIONS
958
959      C
960      1      LF(1) = Y(2)
961      1      LF(2)=-Y(1)*Y(4)-Y(2)*Y(3)-Y(3)*(Y(2)-Y(2))-Y(4)*(Y(1)-Y(1))
962      1      +SIN(Y(5)*TN)
963      RETURN
964      END
965
966      SUBROUTINE WRITES
967      INTEGER IJTV(20)
968      INTEGER QBV,XACTIC,SKIP,IBIG(135),XACTRV
969      REAL      RBIG(204),L8WER,SVEC( 462),LF,IC,IIC,C( 462),Y(20,21)
970      COMMON    IIC(20),IC(20),YVEC( 420),YNL( 80),LF(20),S(21,22),
971      1      DELT, SPTRB, PNORM, TSTART, TSTOP,
972      1      DET,  SMALL, ZERO, DETT, TRACE,
973      2      DZERO, CBNV, DPTRB, DTEMPS, DN1,
974      3H,RN1,RN2,T,
975      4TAVG,TL,TN,TBMT,TEM,TEMP,TTEM,TBV( 21),BV( 20),
976      5 UPPER(20),L8WER(20),PTRB(20),AUX(10),CQBV(20),
977      6DIC(20),YTPRB(20),DELTP,DELT, TNORM, SNORM, ANORM, TBVK, DOT,
978      1      IOUT, LIN, IQBVS, LITER, NORMRD,
979      1      NBV,  NEQ, NCN, NWRITE, SKIP,
980      1      ITRACE, LIMIT, IVARY, IAF(2),
981      1      INVECT, IXTRA,
982      1JXTRA,KXTRA,NOUT,NL,NSPACE,NRCD,
983      2NRSD,NRYD,I,II,ICOUNT,IN1,IN2,INTKEY,IPUNT,IQ,IS,ISUB,ITEMP,ITER,
984      3 J,JJ,JQ,JSUB,K,KK,KOUNT,KOUT,KQ,KTEM,MITER,NBVM,NCOL,NRANKC,
985      4 NRWS,QBV(20),XACTBV(21),XACTIC(20),IQBV(20),NR,IG0,NE,NI
986      EQUIVALENCE (YVEC,Y),(S,SVEC),(YVEC,C),(IOUT,IBIG),(DELT,RBIG)
987      EQUIVALENCE (LF,IJTV)
988      C      WRITES SHOULD NOT BE ENTERED WITH LIMIT = 3
989      GO TO (172,200,200,230),LIMIT
990      172 IF(IOUT=1)182,174,174
991      174 WRITE(6,550)
992      180 DO 180 I=1,NRWS
993      180 WRITE(6,800) I,S(I,NCOL),(S(I,J),J=1,NRANKC)
994      182 RETURN
995      200 IF (IPUNT=2) 201,205,201
996      201 CONTINUE
997      IF (IOUT=1) 182,182,202
998      202 DO 203 I=1,NRANKC
999      203 WRITE(6,360) I,YNL(I+60),IJTV(I)
1000     204 WRITE(6,650) (S(I,NCOL),I=1,NRANKC)
1001     211 WRITE(6,370)DOT,ANORM
1002     212 WRITE(6,380)(DIC(I),I=1,NVECT)
1003     RETURN
1004     205 LIMIT = 3
1005     345 WRITE(6,340)
1006     RETURN

```

```
1003 230 M=1
1004  IF (IBUT=3)232,232,231
1005 231 IF (ITER=MITER) 234,232,232
1006 234 M = NRANKC
1007 232 DO 233 J=1,M
1008 233 WRITE(6,700) IAF(IGO),TL,(Y(I,J),I=1,NBUT)
1009  RETURN
1010 340 FORMAT(44H PUNT... ILL CONDITIONED IPUNT RETURNED AS 2)
1011 360 FORMAT(10X,I5,8HHTH PIVOT,E15.6,I6)
1012 370 FORMAT (1X/3X,4HD0T ,E15.7,15X,7H ANORM,E15.7)
1013 380 FORMAT (/,11H DIC VECT0R,(1X, 7E15.7))
1014 550 FORMAT (1X// 2X,11HSAVE MATRIX,/15X,46HBOUNDARY VALUE,UNPTRBD SOLNS, PTRBD SOLNS.....)
1015 650 FORMAT(1X/3X,11HCONSTANTS , 7E15.7/(14X, 7E15.7))
1016 700 FORMAT (1X,A2,8E15.7/(20X,7E15.7))
1017 800 FORMAT(3X,I2, 7E14.6/(5X, 7E14.6))
1018
1019  END
```

EXAMPLE APPLICATION

To illustrate in an explicit fashion the use of the program and, in particular, the programming of the governing equations, consider the damped harmonic oscillator with an impressed forcing function.

$$\ddot{x}(t) + \mu \dot{x}(t) + \xi x(t) = \sin \omega t$$

the second order equation is converted to a system of two first order equations by the transformation

$$y_1(t) = x(t)$$

$$y_2(t) = \dot{x}(t)$$

The resulting system is seen to be

$$\dot{y}_1(t) = y_2(t)$$

$$\dot{y}_2(t) = \sin \omega t - \mu y_2(t) - \xi y_1(t)$$

For purposes of identifying the parameters μ , ξ and ω from an observed response of the system to a given excitation, let us denote these constants as variables, i.e., elements of a state variable vector,

$$y_3 = \mu$$

$$y_4 = \xi$$

$$y_5 = \omega$$

It follows that those "variables" obey the equations

$$\dot{y}_3(t) = 0$$

$$\dot{y}_4(t) = 0$$

$$\dot{y}_5(t) = 0$$

Note that:

- a) if μ , ξ and ω are specified then the system

$$\dot{y}_1 = y_2$$

$$\dot{y}_2 = \sin y_5(t) - y_3(t) \cdot y_2(t) - y_4(t) \cdot y_1(t)$$

$$\dot{y}_3 = 0 \quad y_3(0) = \mu$$

$$\dot{y}_4 = 0 \quad y_4(0) = \xi$$

$$\dot{y}_5 = 0 \quad y_5(0) = \omega$$

is linear or nonlinear, as you wish to call it.

- b) If say, μ and ξ are not specified, then the same system is nonlinear for the identification problem. In such a case, the linearized system is constructed from a previous approximation y_0 to be

$$\dot{y}_1 = y_2(t)$$

$$\dot{y}_2 = \sum_{j=1}^2 a_{2j}(t) \cdot y_j(t) + f_2(t)$$

$$\dot{y}_3 = 0$$

$$\dot{y}_4 = 0$$

$$\dot{y}_5 = 0$$

where

$$f_2(t) = \sin \omega t - y_{o_3}(t) \cdot y_{o_2}(t) - y_{o_4}(t) \cdot y_{o_1}(t) - \sum_{j=1}^4 a_{2j}^0(t) \cdot y_{o_j}(t)$$

with

$$a_{2j}^0(t) = \frac{\partial}{\partial y_j} [\sin \omega t - y_3(t) \cdot y_2(t) - y_4(t) \cdot y_1(t)] \Big|_{y=y_0} \quad (5.9)$$

such that

$$a_{21}^0(t) = -y_{o_4}(t)$$

$$a_{22}^0(t) = -y_{o_3}(t)$$

$$a_{23}^0(t) = -y_{o_2}(t)$$

$$a_{24}^0(t) = -y_{o_1}(t)$$

The nonlinear system can be programmed as

$$DY(1) = Y(2)$$

$$DY(2) = \sin(Y(5)*T) - Y(2)*Y(3) - Y(1)*Y(4).$$

The linearized system can be programmed as

$$LF(1) = Y(2)$$

$$\begin{aligned} LF(2) = & \sin(Y_0(5)*T) - Y_0(2)*Y_0(3) - Y_0(4)*Y_0(1) \\ & + (Y(1) - Y_0(1)) * (-Y_0(4)) \\ & + (Y(2) - Y_0(2)) * (-Y_0(3)) \\ & + (Y(3) - Y_0(3)) * (-Y_0(2)) \\ & + (Y(4) - Y_0(4)) * (-Y_0(1)). \end{aligned}$$

SAMPLE INPUTSAMPLE PROBLEM #1

INPUT DATA CARD 4 20
 INPUT DATA CARD 6 15
 INPUT DATA CARD 7 2
 INPUT DATA CARD 8 3

BLANK DATA CARD

INPUT DATA CARD 1 0.2000000E+01
 INPUT DATA CARD 12 0.9999999E-04
BLANK DATA CARD

INPUT DATA CARD 1 0 0.1000000E+01 -0.2200000E+00 1
 INPUT DATA CARD 2 0 0.2000000E+01 0.3500000E-01 1
 INPUT DATA CARD 3 0 0.3000000E+01 -0.4740000E+00 1
 INPUT DATA CARD 4 0 0.4000000E+01 -0.5890000E+00 1
 INPUT DATA CARD 5 0 0.5000000E+01 0.3929999E+00 1
 INPUT DATA CARD 6 0 0.6000000E+01 0.1596999E+01 1
 INPUT DATA CARD 7 0 0.7000000E+01 0.1452000E+01 1
 INPUT DATA CARD 8 0 0.8000000E+01 -0.3880000E+00 1
 INPUT DATA CARD 9 0 0.9000000E+01 -0.2323999E+01 1
 INPUT DATA CARD 10 0 0.1000000E+02 -0.2273999E+01 1
 INPUT DATA CARD 11 0 0.1100000E+02 0.8800000E-01 1
 INPUT DATA CARD 12 0 0.1200000E+02 0.2710999E+01 1
 INPUT DATA CARD 13 0 0.1300000E+02 0.2997000E+01 1
 INPUT DATA CARD 14 0 0.1400000E+02 0.4010000E+00 1
 INPUT DATA CARD 15 0 0.1500000E+02 -0.2816000E+01 1

BLANK DATA CARD

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INPUT DATA CARD 1 0 0.5000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 2 0 0.1000000E+01 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 3 0 0.9999999E-01 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 4 0 0.2999999E+01 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 5 -1 0.1000000E+01 0.0000000E+00 0.0000000E+00 0.0000000E+00

BLANK DATA CARD

	TBV	B-V	QBV	XCTBV
1	0.1000000E+01	-0.2200000E+00	0	1
2	0.2000000E+01	0.3500000E-01	0	1
3	0.3000000E+01	-0.4740000E+00	0	1
4	0.4000000E+01	-0.5890000E+00	0	1
5	0.5000000E+01	0.3929999E+00	0	1
6	0.6000000E+01	0.1596999E+01	0	1
7	0.7000000E+01	0.1452000E+01	0	1
8	0.8000000E+01	-0.3880000E+00	0	1
9	0.9000000E+01	-0.2323999E+01	0	1
10	0.1000000E+02	-0.2273999E+01	0	1
11	0.1100000E+02	0.8800000E-01	0	1
12	0.1200000E+02	0.2710999E+01	0	1
13	0.1300000E+02	0.2997000E+01	0	1
14	0.1400000E+02	0.4010000E+00	0	1
15	0.1500000E+02	-0.2816000E+01	0	1

Y(1)	IC	XCTIC	PTRB	UPPER	LOWER
1	0.5000000E+00	0	0.1700000E+01	0.0000000E+00	0.0000000E+00
2	0.1000000E+01	0	0.1200000E+01	0.0000000E+00	0.0000000E+00
3	0.9999996E-01	0	0.1200000E+01	0.0000000E+00	0.0000000E+00
4	0.1299999E+01	0	0.1200000E+01	0.0000000E+00	0.0000000E+00
5	0.1000000E+01	-1	0.0000000E+00	0.0000000E+00	0.0000000E+00

IBUT	0	IIN	0	DIGBVS	0	LITER	20	NORMRD	0
NBV	15	NEQ	2	NCN	3	NWRITE	5	SKIP	0
DELT	0.200000E-01	SPTRB	0.120000E+01	PNORM	0.000000E+00	TSTART	0.000000E+00	TSTOP	0.150000E+02

SAMPLE OUTPUT

GENERATED

NRANKC 5

AUX

0.0000000E+00							
0.0000000E+00	0.0000000E+00						

ITER 1 OF 20

TIME SOLUTION

0.0000000E+00	0.5000000E+00	0.1000000E+01	0.9999996E-01	0.1299999E+01	0.1000000E+01

ITER 2 OF 20

TIME SOLUTION

0.0000000E+00	0.8341141E+00	-0.9481580E-01	0.3672728E+00	0.1158999E+01	0.1000000E+01

ITER 3 OF 20

TIME SOLUTION

0.0000000E+00	-0.2206499E+00	0.2258086E+01	0.1949387E+00	0.8618612E+00	0.1000000E+01

ITER 4 OF 20

TIME SOLUTION

0.0000000E+00	-0.5682859E+00	0.3256903E+00	0.2366757E+00	0.9734848E+00	0.1000000E+01

ITER 5 OF 20

TIME SOLUTION

0.0000000E+00	0.1362946E+01	0.316879E+00	0.2017888E+00	0.1000775E+01	0.1000000E+01

ITER 6 OF 20

TIME SOLUTION

0.0000000E+00	0.9985237E+00	0.5017281E+00	0.1999071E+00	0.9998708E+00	0.1000000E+01

ITER 7 OF 20

TIME SOLUTION

0.0000000E+00	0.1002094E+01	0.5021760E+00	0.1999351E+00	0.9998615E+00	0.1000000E+01

ITER 8 OF 20

TIME SOLUTION

0.0000000E+00	0.1001977E+01	0.502004E+00	0.1999393E+00	0.9998688E+00	0.1000000E+01

ITER	9	MF	9	SOLUTION		
TIME						
0.000000E+00	0.100196E+01	0.5020053E+00	0.1999387E+00	0.9998682E+00	0.1000000E+01	
0.5999996E+01	0.104679E+01	0.3955273E+00				
0.1999999E+00	0.108134E+01	0.2970799E+00				
0.2999998E+00	0.1106464E+01	0.207300E+00				
0.3999997E+00	0.1123111E+01	0.126487E+00				
0.4999996E+00	0.1132145E+01	0.5561259E-01				
0.5999995E+00	0.1134547E+01	-0.591302E-02				
0.6999994E+00	0.1131251E+01	-0.5815910E-01				
0.7999993E+00	0.1123205E+01	-0.1011595E+00				
0.8999992E+00	0.1111300E+01	-0.1354223E+00				
BV	0.1000000E+01	0.1096383E+01	-0.1615243E+00			
1TH BV	-0.2200000E+00	u(Y)	-0.2224722E+00			
0.1099998E+01	0.1079234E+01	-0.1801722E+00				
0.1199995E+01	0.1060560E+01	-0.1921865E+00				
0.1299993E+01	0.1040975E+01	-0.1984817E+00				
0.1399990E+01	0.1021013E+01	-0.2000461E+00				
0.1499986E+01	0.1001084E+01	-0.1973221E+00				
0.1599985E+01	0.9815115E+00	-0.1931845E+00				
0.1699983E+01	0.9624975E+00	-0.1869200E+00				
0.1799980E+01	0.9441419E+00	-0.1802057E+00				
0.1899978E+01	0.9264361E+00	-0.1740888E+00				
BV	0.2000000E+01	0.9092662E+00	-0.1695670E+00			
2TH BV	0.3500000E+01	u(Y)	0.3405410E-01			
0.2099998E+01	0.8924338E+00	-0.1675733E+00				
0.2199995E+01	0.8756330E+00	-0.1689528E+00				
0.2299993E+01	0.8585352E+00	-0.1744520E+00				
0.2399990E+01	0.8405850E+00	-0.1847035E+00				
0.2499988E+01	0.8213884E+00	-0.2002143E+00				
0.2599985E+01	0.8003575E+00	-0.2214570E+00				
0.2699983E+01	0.776920E+00	-0.2423621E+00				
0.2799980E+01	0.7504862E+00	-0.2813123E+00				
0.2899978E+01	0.7204616E+00	-0.3201411E+00				
BV	0.3000000E+01	0.6802594E+00	-0.3546433E+00			
3TH BV	-0.4740000E+00	u(Y)	-0.47421429E+00			
0.3099998E+01	0.6473477E+00	-0.4144333E+00				
0.3199995E+01	0.6032124E+00	-0.4690139E+00				
0.3299993E+01	0.5534061E+00	-0.5277419E+00				
0.3399990E+01	0.4975510E+00	-0.5898474E+00				
0.3499988E+01	0.4353530E+00	-0.6544446E+00				
0.3599985E+01	0.3666114E+00	-0.7205452E+00				
0.3699983E+01	0.2912290E+00	-0.780732E+00				
0.3799980E+01	0.2092201E+00	-0.8528810E+00				
0.3899978E+01	0.1207164E+00	-0.9167672E+00				
BV	0.4000000E+01	0.2594789E-01	-0.9775091E+00			
4TH BV	-0.5890000E+00	u(Y)	-0.5873049E+00			
0.4099998E+01	-0.7466060E+01	-0.1033821E+01				
0.4199995E+01	-0.1806274E+00	-0.1084472E+01				
0.4299993E+01	-0.2913247E+00	-0.1124238E+01				
0.4399990E+01	-0.4060053E+00	-0.1163938E+01				
0.4499988E+01	-0.5238056E+00	-0.1190456E+01				
0.4599985E+01	-0.6437652E+00	-0.1206755E+01				
0.4699983E+01	-0.7647842E+00	-0.1211902E+01				
0.4799980E+01	-0.8857359E+00	-0.1205082E+01				
0.4899978E+01	-0.1005378E+01	-0.1185610E+01				
BV	0.5000000E+01	-0.1122442E+01	-0.1152945E+01			
5TH BV	0.3929999E+00	u(Y)	0.3932884E+00			

0.5099998E+01 -0.1235535E+01 -0.1106721E+01
 0.5199995E+01 -0.1343318E+01 -0.1046728E+01
 0.5299993E+01 -0.1444417E+01 -0.9729415E+00
 0.5399990E+01 -0.1537444E+01 -0.8855130E+00
 0.5499988E+01 -0.1621064E+01 -0.7847824E+00
 0.5599985E+01 -0.1693966E+01 -0.6712782E+00
 0.5699983E+01 -0.1754907E+01 -0.545/152E+00
 0.5799980E+01 -0.1802727E+01 -0.4089893E+00
 0.5899978E+01 -0.1836363E+01 -0.2621717E+00
 BV 0.6000000E+01 -0.1854862E+01 -0.1064612E+00
 6TH BV 0.1596999E+01 0(Y) 0.1596487E+01
 0.6099998E+01 -0.1857403E+01 0.5667403E+01
 0.6199995E+01 -0.1843321E+01 0.2257376E+00
 0.6299993E+01 -0.1812166E+01 0.3990713E+00
 0.6399990E+01 -0.1763417E+01 0.5749087E+00
 0.6499988E+01 -0.1697046E+01 0.7513948E+00
 0.6599985E+01 -0.1613173E+01 0.9266071E+00
 0.6699983E+01 -0.1511873E+01 0.1098574E+01
 0.6799980E+01 -0.1393623E+01 0.1255306E+01
 0.6899978E+01 -0.1259446E+01 0.1424815E+01
 BV 0.7000000E+01 -0.1108921E+01 0.1575169E+01
 7TH BV 0.1452000E+01 0(Y) 0.1450824E+01
 0.7099998E+01 -0.9443466E+00 0.1714379E+01
 0.7199995E+01 -0.7664738E+00 0.1840643E+01
 0.7299993E+01 -0.5767014E+00 0.1952210E+01
 0.7399990E+01 -0.3765757E+00 0.2047459E+01
 0.7499988E+01 -0.1678028E+00 0.2124904E+01
 0.7599985E+01 -0.4776811E+01 0.2183222E+01
 0.7699983E+01 -0.2681655E+00 0.2221274E+01
 0.7799980E+01 -0.4913152E+00 0.2238115E+01
 0.7899978E+01 -0.7150569E+00 0.2233017E+01
 BV 0.8000000E+01 -0.9372235E+00 0.2205469E+01
 8TH BV -0.3880000E+00 0(Y) -0.3887004E+00
 0.8099998E+01 -0.1155443E+01 0.2155214E+01
 0.8199995E+01 -0.1367499E+01 0.2082231E+01
 0.8299993E+01 -0.1571136E+01 0.1985742E+01
 0.8399990E+01 -0.1764106E+01 0.1869228E+01
 0.8499988E+01 -0.1944255E+01 0.1730418E+01
 0.8599985E+01 -0.2109501E+01 0.1571290E+01
 0.8699983E+01 -0.2257870E+01 0.1393060E+01
 0.8799980E+01 -0.2387518E+01 0.1197179E+01
 0.8899978E+01 -0.2496763E+01 0.9853167E+00
 BV 0.9000000E+01 -0.2584121E+01 0.7592960E+00
 9TH BV -0.2323999E+01 0(Y) -0.2323474E+01
 0.9099996E+01 -0.2548235E+01 0.5212857E+00
 0.9199995E+01 -0.2682040E+01 0.2734633E+00
 0.9299993E+01 -0.2702671E+01 0.1820665E+01
 0.9399990E+01 -0.2691508E+01 -0.2419837E+00
 0.9499988E+01 -0.2654137E+01 -0.5045104E+00
 0.9599985E+01 -0.2596606E+01 -0.7667056E+00
 0.9699983E+01 -0.2506938E+01 -0.1023858E+01
 0.9799980E+01 -0.2385620E+01 -0.1279242E+01
 0.9899978E+01 -0.2245364E+01 -0.1524151E+01
 BV 0.1000000E+02 -0.2081108E+01 -0.1757979E+01
 10TH BV -0.2273999E+01 0(Y) -0.2273366E+01
 0.1010000E+02 -0.1894177E+01 -0.1978025E+01
 0.1020000E+02 -0.1686032E+01 -0.2181865E+01
 0.1029999E+02 -0.1458412E+01 -0.2367146E+01
 0.1039999E+02 -0.1213286E+01 -0.2531680E+01

OF
POOR
PAGE IS
QUALITY

0.1049999E+02	0.9528285E+00	-0.2673456E+01
0.1059999E+02	0.6794098E+00	-0.2790683E+01
0.1069999E+02	0.395562E+00	-0.2881793E+01
0.1079999E+02	0.103965E+00	-0.2945473E+01
0.1089999E+02	-0.1925829E+00	-0.298678E+01
BV	0.1100000E+02	-0.4912672E+00
11TH BV	0.8800000E-01	0(Y)
0.1110000E+02	-0.7889924E+00	-0.2962896E+01
0.1120000E+02	-0.1082849E+01	-0.2909283E+01
0.1129999E+02	-0.1369855E+01	-0.2825947E+01
0.1139999E+02	-0.1647054E+01	-0.2713345E+01
0.1149999E+02	-0.1911565E+01	-0.2572243E+01
0.1159999E+02	-0.216052E+01	-0.243715E+01
0.1169998E+02	-0.2391315E+01	-0.2209130E+01
0.1179998E+02	-0.2601955E+01	-0.1950145E+01
0.1189998E+02	-0.2788701E+01	-0.1748688E+01
BV	0.1200000E+02	-0.2956674E+01
12TH BV	0.2710999E+01	Q(Y)
0.1210000E+02	-0.3085514E+01	-0.1207262E+01
0.1220000E+02	-0.3191608E+01	-0.9124132E+00
0.1229999E+02	-0.3267573E+01	-0.6051509E+00
0.1239999E+02	-0.3312315E+01	-0.2884501E+00
0.1249999E+02	-0.3325647E+01	0.3453169E-01
0.1259999E+02	-0.3305265E+01	0.360383E+00
0.1269999E+02	-0.3252849E+01	0.5867484E+00
0.1279999E+02	-0.3166043E+01	0.1009307E+01
0.1289999E+02	-0.3051248E+01	0.1325108E+01
BV	0.1300000E+02	-0.2903301E+01
13TH BV	0.2997000E+01	W(Y)
0.1310000E+02	-0.272556E+01	0.1923523E+01
0.1320000E+02	-0.251914E+01	0.2199775E+01
0.1329999E+02	-0.2286139E+01	0.2456767E+01
0.1339999E+02	-0.2028517E+01	1.2691709E+01
0.1349999E+02	-0.1748615E+01	0.2902020E+01
0.1359999E+02	-0.144900E+01	0.3085340E+01
0.1369998E+02	-0.1132507E+01	0.3259571E+01
0.1379998E+02	-0.8021181E+00	0.336288E+01
0.1389998E+02	-0.4610199E+00	0.3453771E+01
BV	0.1400000E+02	-0.1124052E+00
14TH BV	0.401010000E+00	Q(Y)
0.1410000E+02	0.2401262E+00	0.3537474E+01
0.1420000E+02	0.5991799E+00	0.3521432E+01
0.1429999E+02	0.9432398E+00	0.3439107E+01
0.1439999E+02	0.1286790E+01	0.3391363E+01
0.1449999E+02	0.1620354E+01	0.3243336E+01
0.1459999E+02	0.1946528E+01	0.3123730E+01
0.1469999E+02	0.2244014E+01	0.2940795E+01
0.1479999E+02	0.2527653E+01	0.2727118E+01
0.1489999E+02	0.2788666E+01	0.2484614E+01
BV	0.1500000E+02	0.3023731E+01
15TH BV	-0.2816000E+01	W(Y)
		-0.2815995E+01

SAMPLE INPUT

SAMPLE PROBLEM #2

INPUT DATA CARD 4 10
 INPUT DATA CARD 8 9
 INPUT DATA CARD 7 2
 INPUT DATA CARD 1 4
 INPUT DATA CARD 9 25
 INPUT DATA CARD 6 11
 BLANK DATA CARD

INPUT DATA CARD 1 0.2000000E-01
 INPUT DATA CARD 5 0.1500000E+02
 INPUT DATA CARD 12 0.9999999E-03
 BLANK DATA CARD

INPUT DATA CARD 1 1 0.1000000E+01 0.1093660E-01 1
 INPUT DATA CARD 2 1 0.2000000E+01 0.9092662E+00 1
 INPUT DATA CARD 3 2 0.3000000E+01 -0.3646433E+00 1
 INPUT DATA CARD 4 1 0.4000000E+01 0.2594789E-01 1
 INPUT DATA CARD 5 2 0.5000000E+01 -0.1152945E+01 1
 INPUT DATA CARD 6 1 0.8000000E+01 0.9372235E+00 1
 INPUT DATA CARD 7 2 0.8000000E+01 0.2205468E+01 1
 INPUT DATA CARD 8 1 0.1100000E+02 -0.4912671E+00 1
 INPUT DATA CARD 9 2 0.1100000E+02 -0.2986642E+01 1
 INPUT DATA CARD 10 1 0.1500000E+02 0.3023730E+01 1
 INPUT DATA CARD 11 2 0.1500000E+02 0.2215436E+01 1
 BLANK DATA CARD

INPUT DATA CARD 1 0 0.7000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 2 0 0.7000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 3 -1 0.2000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 4 -1 0.1000000E+01 0.0000000E+00 0.0000000E+00 0.0000000E+00
 INPUT DATA CARD 5 -1 0.1000000E+01 0.0000000E+00 0.0000000E+00 0.0000000E+00
 BLANK DATA CARD

	TBV	B-V	QBV	XCTBV
1	0.1000000E+01	0.1093660E-01	1	1
2	0.2000000E+01	0.9092662E+00	1	1
3	0.3000000E+01	-0.3646433E+00	2	1
4	0.4000000E+01	0.2594789E-01	1	1
5	0.5000000E+01	-0.1152945E+01	2	1
6	0.8000000E+01	0.9372235E+00	1	1
7	0.8000000E+01	0.2205468E+01	2	1
8	0.1100000E+02	-0.4912671E+00	1	1
9	0.1100000E+02	-0.2986642E+01	2	1
10	0.1500000E+02	0.3023730E+01	1	1
11	0.1500000E+02	0.2215436E+01	2	1

Y()	IC	XCTIC	PTR8	UPPER	LOWER
1	0.7000000E+00	0	0.1200000E+01	0.0000000E+00	0.0000000E+00
2	0.7000000E+00	0	0.1200000E+01	0.0000000E+00	0.0000000E+00
3	0.2000000E+00	-1	0.0000000E+00	0.0000000E+00	0.0000000E+00
4	0.1000000E+01	-1	0.0000000E+00	0.0000000E+00	0.0000000E+00

5 0.1000000E+01 -1 0.0000000E+00 0.0000000E+00 0.0000000E+00

IBUT 4 LIN 01GBVS 0 LITER 10 NORMRD 0

N8V 11 NEQ 2 NCN 3 NWRITE 25 SKIP 0

DELT 0.200000E+01 SPTRB 0.120000E+01 PNORM 0.000000E+00 TSTART 0.000000E+00 TSTOP 0.150000E+02

GENERATED

NRANKC 3

AUX
0.000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.000000E+00 0.0000000E+00

REPEATED TIMES ARE PARTICULAR SOLUTIONS

SAMPLE OUTPUT

ITER 1 NF 10

SOLUTION

0.0000000E+00	0.7000000E+00	0.7000000E+00	0.2000000E+00	0.1000000E+01	0.1000000E+01
0.000000E+00	0.8399999E+00	0.7000000E+00	0.2000000E+00	0.1000000E+01	0.1000000E+01
0.0000000E+00	0.7000000E+00	0.8399999E+00	0.2000000E+00	0.1000000E+01	0.1000000E+01
0.4999956E+00	0.956265E+00	0.3497854E+00			
0.4999996E+00	0.1079678E+01	0.2859135E+00			
0.4999996E+00	0.1020139E+01	0.4604279E+00			
BV	0.100000E+01	0.1075538E+01	0.1511326E+00		
BV	0.1000000E+01	0.1155195E+01	0.4435071E-01		
BV	0.1000000E+01	0.1182330E+01	0.2094327E+00		
	0.1499988E+01	0.1125338E+01	0.5862120E-01		
	0.1499988E+01	0.1146852E+01	-0.6211286E-01		
	0.1499988E+01	0.1246091E+01	0.5597012E-01		
BV	0.2000000E+01	0.1135816E+01	-0.2356429E-01		
BV	0.2000000E+01	0.1099705E+01	-0.1287959E+00		
BV	0.2000000E+01	0.1241062E+01	-0.8075535E-01		
	0.2439988E+01	0.1087675E+01	-0.1882297E+00		
	0.2499988E+01	0.1007850E+01	-0.2549233E+00		
	0.2499988E+01	0.1154379E+01	-0.2814492E+00		
BV	0.3000000E+01	0.9264440E+00	-0.4766998E+00		
BV	0.3000000E+01	0.8256610E+00	-0.4929921E+00		
BV	0.3000000E+01	0.9427206E+00	-0.5808079E+00		
	0.3499988E+01	0.5959560E+00	-0.8526036E+00		
	0.3499988E+01	0.4996783E+00	-0.8194996E+00		
	0.3499988E+01	0.5628073E+00	-0.9423068E+00		
BV	0.4000000E+01	0.7711613E-01	-0.1207367E+01		
BV	0.4000000E+01	0.7347226E-02	-0.1137285E+01		
BV	0.4000000E+01	-0.6967612E-02	-0.1263138E+01		
	0.4499988E+01	-0.5835585E+00	-0.1395411E+01		
	0.4499988E+01	-0.6130923E+00	-0.1308206E+01		
	0.4499988E+01	-0.6708438E+00	-0.1407490E+01		
BV	0.5000000E+01	-0.1268603E+01	-0.1287576E+01		
BV	0.5000000E+01	-0.1254860E+01	-0.1205191E+01		
BV	0.5000000E+01	-0.1351066E+01	-0.1257304E+01		
	0.5499988E+01	-0.1811308E+01	-0.8243835E+00		
	0.5499988E+01	-0.1761617E+01	-0.7655500E+00		
	0.5499988E+01	-0.1870204E+01	-0.7628422E+00		
	0.5999975E+01	-0.2040695E+01	-0.5088079E-01		
	0.5999975E+01	-0.1969967E+01	-0.2705427E-01		
	0.5999975E+01	-0.2064457E+01	0.2462750E-01		

0.6499963E+01	-0.1835453E+01	0.8801509E+00
0.6499963E+01	-0.1762322E+01	0.8667561E+00
0.6499963E+01	-0.1822042E+01	0.9507104E+00
0.6999950E+01	-0.1172173E+01	0.1740053E+01
0.6999950E+01	-0.1113821E+01	0.1696112E+01
0.6999950E+01	-0.1128167E+01	0.1789709E+01
0.7499938E+01	-0.1483383E+00	0.2284041E+01
0.7499938E+01	-0.1169468E+00	0.2222708E+01
0.7499938E+01	-0.8689070E-01	0.2303221E+01
BY	0.8000900E+01	0.1027084E+01
BY	0.8000900E+01	0.1026773E+01
BY	0.8000000E+01	0.1090006E+01
0.8499988E+01	0.2076712E+01	0.1781559E+01
0.8499988E+01	0.2047807E+01	0.1732094E+01
0.8499988E+01	0.2126322E+01	0.1742690E+01
0.8999975E+01	0.2724151E+01	0.7391631E+00
0.8999975E+01	0.2676120E+01	0.7132661E+00
0.8999975E+01	0.2750165E+01	0.6858172E+00
0.9499963E+01	0.2768405E+01	-0.5844616E+00
0.9499963E+01	0.2714257E+01	-0.5830164E+00
0.9499963E+01	0.2767006E+01	-0.6384907E+00
0.9999950E+01	0.2145331E+01	-0.1873320E+01
0.9999950E+01	0.2098269E+01	-0.1847485E+01
0.9999950E+01	0.2119461E+01	-0.1915392E+01
0.1049994E+02	0.9568134E+00	-0.2793928E+01
0.1049994E+02	0.9271247E+00	-0.2752050E+01
0.1049994E+02	0.9148225E+00	-0.2815383E+01
BY	0.1100010E+02	-0.5428562E+00
BY	0.1100010E+02	-0.5499218E+00
BY	0.1100000E+02	-0.5896646E+00
0.1149999E+02	-0.2001231E+01	-0.2625164E+01
0.1149999E+02	-0.1986194E+01	-0.2585100E+01
0.1149999E+02	-0.2041503E+01	-0.2602084E+01
0.1199998E+02	-0.3053777E+01	-0.1487646E+01
0.1199998E+02	-0.3022252E+01	-0.1462855E+01
0.1199998E+02	-0.3078757E+01	-0.1451042E+01
0.1249996E+02	-0.3416236E+01	0.8121765E-01
0.1249996E+02	-0.3377142E+01	0.8642358E-01
0.1249996E+02	-0.3421565E+01	0.1215385E+00
0.1299995E+02	-0.2962417E+01	0.1709506E+01
0.1299995E+02	-0.2925590E+01	0.1695791E+01
0.1299995E+02	-0.2948729E+01	0.1743810E+01
0.1349994E+02	-0.1764860E+01	0.2991118E+01
0.1349994E+02	-0.1738658E+01	0.2963490E+01
0.1349994E+02	-0.1737151E+01	0.3011996E+01
0.1399993E+02	-0.8616453E-01	0.3588797E+01
0.1399993E+02	-0.7567459E-01	0.3555022E+01
0.1399993E+02	-0.5221295E-01	0.3592670E+01
0.1449991E+02	0.1678929E+01	0.3323691E+01
0.1449991E+02	0.1672778E+01	0.3292223E+01
0.1449991E+02	0.1710635E+01	0.3311273E+01
BY	0.1500000E+02	0.3098001E+01
BY	0.1500000E+02	0.3078233E+01
BY	0.1500000E+02	0.3120300E+01

SAVE MATRIX

BOUNDARY VALUE,UNPTRBD SBLN, PTRBD SBLNS.....
 1 0.100000E+01 -0.100000E+01 0.100000E+01 0.100000E+01

2	0.221544E+01	0.222730E+01	0.220524E+01	0.220302E+01
3	0.302373E+01	0.309800E+01	0.307823E+01	0.312030E+01
4	-0.298664E+01	-0.308358E+01	-0.303695E+01	-0.308139E+01
5	-0.491267E+00	-0.542856E+00	-0.549922E+00	-0.589665E+00
6	0.220547E+01	0.232224E+01	0.225946E+01	0.230937E+01
7	0.937223E+00	0.102708E+01	0.102677E+01	0.109001E+01
8	-0.115294E+01	-0.128758E+01	-0.120519E+01	-0.125730E+01
9	0.259479E-01	0.771161E-01	0.734723E-02	0.696761E-02
10	-0.364643E+00	-0.476700E+00	-0.492992E+00	-0.580807E+00
11	0.909266E+00	0.113582E+01	0.109970E+01	0.124106E+01
12	0.109366E-01	0.107554E+01	0.115520E+01	0.118233E+01
	1TH PIVET	0.100000E+01	101	
	2TH PIVET	-0.242767E-01	203	
	3TH PIVET	-0.400273E-01	302	

CONSTANTS 0.3166437E+00 0.2127744E+01 -0.1444387E+01

DET 0.0000000E+00 ANORM 0.3600357E+00

DIC VECTOR

0.2978843E+00 -0.2022144E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00

REPEATED TIMES ARE PARTICULAR SOLUTIONS

	ITER	2	OF	10
	TIME	SOLUTION		
0.0000000E+00	0.9978843E+00	0.4977856E+00	0.2000000E+00	0.1000000E+01 0.1000000E+01
0.0000000E+00	0.1197461E+01	0.4977856E+00	0.2000000E+00	0.1000000E+01 0.1000000E+01
0.0000000E+00	0.9978843E+00	0.5973426E+00	0.2000000E+00	0.1000000E+01 0.1000000E+01
0.4999996E+00	0.1126580E+01	0.5407673E-01		
0.4999996E+00	0.1302536E+01	-0.3698122E-01		
0.4999996E+00	0.1172019E+01	0.1327531E+00		
BV	0.1000000E+01	0.1090760E+01	-0.1602647E+00	
BV	0.1000000E+01	0.1204340E+01	-0.3125080E+00	
BV	0.1000000E+01	0.1166723E+01	-0.1188216E+00	
	0.1499988E+01	0.9966838E+00	-0.1944188E+00	
	0.1499988E+01	0.1027365E+01	-0.3665591E+00	
	0.1499988E+01	0.1082568E+01	-0.1963261E+00	
BV	0.2000000E+01	0.9069713E+00	-0.1648426E+00	
BV	0.2000000E+01	0.2554781E+00	-0.3148813E+00	
BV	0.2000000E+01	0.9818044E+00	-0.2055335E+00	
	0.2499988E+01	0.8215081E+00	-0.1954806E+00	
	0.2499988E+01	0.7076619E+00	-0.2905639E+00	
	0.2499988E+01	0.8689127E+00	-0.2617813E+00	
BV	0.3000000E+01	0.6885145E+00	-0.3609952E+00	
BV	0.3000000E+01	0.5447734E+00	-0.3841960E+00	
BV	0.3000000E+01	0.7000539E+00	-0.4350211E+00	
	0.3499988E+01	0.4389986E+00	-0.6526104E+00	
	0.3499988E+01	0.3016998E+00	-0.6053670E+00	
	0.3499988E+01	0.4153984E+00	-0.7163787E+00	
BV	0.4000000E+01	0.2999910E-01	-0.9777138E+00	
BV	0.4000000E+01	-0.6947887E-01	-0.8777356E+00	
BV	0.4000000E+01	-0.1989930E-01	-0.1017341E+01	
	0.4499988E+01	-0.5203185E+00	-0.1192422E+01	
	0.4499988E+01	-0.5624028E+00	-0.1068035E+01	
	0.4499988E+01	-0.5823882E+00	-0.1200983E+01	
BV	0.5000000E+01	-0.1120245E+01	-0.1156006E+01	
BV	0.5000000E+01	-0.1100595E+01	-0.1038511E+01	
BV	0.5000000E+01	-0.1178872E+01	-0.1134463E+01	

ORIGINAL PAGE IS
A COPY OF

0.5499988E+01 -0.1620492E+01 -0.7880933E+00
 0.5499988E+01 -0.1549582E+01 -0.7042078E+00
 0.5499988E+01 -0.1662362E+01 -0.7443231E+00
 0.5999975E+01 -0.1856837E+01 -0.1092579E+00
 0.5999975E+01 -0.1755064E+01 -0.7531327E-01
 0.5999975E+01 -0.1872784E+01 -0.5556232E-01
 0.6499963E+01 -0.1699203E+01 0.7497174E+00
 0.6499963E+01 -0.1594890E+01 0.7305697E+00
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 0.6999950E+01 -0.1111567E+01 0.1574812E+01
 0.6999950E+01 -0.1028356E+01 0.1512099E+01
 0.6999950E+01 -0.1080273E+01 0.1610119E+01
 0.7499938E+01 -0.1702995E+00 0.2125805E+01
 0.7499938E+01 -0.1255597E+00 0.2038289E+01
 0.7499938E+01 -0.1266064E+00 0.2139440E+01
 BV 0.8000000E+01 0.9355232E+00 0.2207214E+01
 BV 0.8000000E+01 0.9350324E+00 0.2117652E+01
 BY 0.8000000E+01 0.9802646E+00 0.2198066E+01
 0.8499988E+01 -0.1943516E+01 0.1732428E+01
 0.8499988E+01 0.1902238E+01 0.1661880E+01
 0.8499988E+01 -0.1978796E+01 0.1704794E+01
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 0.9999950E+01 -0.2082500E+01 -0.1751527E+01
 0.9999950E+01 -0.2015361E+01 -0.1720620E+01
 0.9999950E+01 -0.2064128E+01 -0.1787455E+01
 0.1049994E+02 0.9542516E+00 -0.2673746E+01
 0.1049994E+02 0.9119142E+00 -0.2613962E+01
 0.1049994E+02 -0.9244131E+00 -0.2689033E+01
 BV 0.1100000E+02 -0.4902771E+00 -0.2987442E+01
 BV 0.1100000E+02 -0.5003212E+00 -0.2920888E+01
 BV 0.1100000E+02 -0.5235572E+00 -0.2985915E+01
 0.1149999E+02 -0.1911017E+01 -0.2573172E+01
 0.1149999E+02 -0.1889516E+01 -0.2516005E+01
 0.1149999E+02 -0.1939668E+01 -0.2556796E+01
 0.1199998E+02 -0.2950526E+01 -0.1487717E+01
 0.1199998E+02 -0.2905504E+01 -0.1452335E+01
 0.1199998E+02 -0.2968323E+01 -0.1461712E+01
 0.1249999E+02 -0.3326244E+01 0.3405523E+01
 0.1249999E+02 -0.3269433E+01 0.4145670E-01
 0.1249999E+02 -0.3329082E+01 0.6272334E-01
 0.1299995E+02 -0.290319E+01 0.1630720E+01
 0.1299995E+02 -0.2851151E+01 0.1611114E+01
 0.1299995E+02 -0.2894033E+01 0.1655135E+01
 0.1349994E+02 -0.1749057E+01 0.2902075E+01
 0.1349994E+02 -0.1711665E+01 0.2862608E+01
 0.1349994E+02 -0.1729390E+01 0.2916963E+01
 0.1399993E+02 -0.1128560E+00 0.3511220E+01
 0.1399993E+02 -0.9790677E-01 0.3462981E+01
 0.1399993E+02 -0.8873010E-01 0.3514023E+01
 0.1449991E+02 0.1620008E+01 0.3274558E+01
 0.1449991E+02 0.1611187E+01 0.3229625E+01
 0.1449991E+02 0.1642563E+01 0.3265780E+01
 BV 0.1500000E+02 0.3023641E+01 0.2215360E+01
 BY 0.1500000E+02 0.2995376E+01 0.2187884E+01

BV 0.1500000E+02 0.3039534E+01 0.2198140E+01

SAVE MATRIX

BBOUNDARY VALUE,UNPTRBD SBLN, PTRBD SBLNS.....

1	0.100000E+01	0.100000E+01	0.100000E+01	0.100000E+01
2	0.221544E+01	0.221536E+01	0.218388E+01	0.219814E+01
3	0.302373E+01	0.302364E+01	0.299538E+01	0.303953E+01
4	-0.298664E+01	-0.298744E+01	-0.292089E+01	-0.298592E+01
5	-0.491267E+00	-0.490277E+00	-0.500321E+00	-0.523557E+00
6	0.220547E+01	0.220721E+01	0.211765E+01	0.219807E+01
7	0.937223E+00	0.935523E+00	0.935032E+00	0.980265E+00
8	-0.115294E+01	-0.115601E+01	-0.103851E+01	-0.113446E+01
9	0.259479E-01	0.299991E-01	0.694789E-01	-0.198993E-01
10	-0.364643E+00	-0.360995E+00	-0.384196E+00	-0.435021E+00
11	0.909266E+00	0.906971E+00	0.855478E+00	0.981804E+00
12	0.109366E-01	0.109076E+01	0.120434E+01	0.116672E+01
	1TH PIVOT	0.100000E+01	101	
	2TH PIVOT	-0.314760E-01	202	
	3TH PIVOT	0.313559E-01	303	

CONSTANTS 0.1002117E+01 -0.2792611E-02 0.6740219E-03

DBT -0.8884858E+00

ANBRM 0.5619149E-03

DIC VECTOR

-0.5578995E-03 0.6705523E-04 0.0000000E+00 0.0000000E+00 0.0000000E+00

REPEATED TIMES ARE PARTICULAR SOLUTIONS

TIME	ITER	3 OF 10	SOLUTION
0.0000000E+00	0.9973264E+00	0.4978526E+00	0.2000000E+00 0.1000000E+01 0.1000000E+01
0.000000E+00	0.1196792E+01	0.4978526E+00	0.2000000E+00 0.1000000E+01 0.1000000E+01
0.0000000E+00	0.9973264E+00	0.5974230E+00	0.2000000E+00 0.1000000E+01 0.1000000E+01
0.4999996E+00	0.1126123E+01	0.5438244E-01	
0.4999996E+00	0.1301975E+01	-0.3662245E-01	
0.4999996E+00	0.1171563E+01	0.1330713E+00	
BV	0.1000000E+01	0.1090500E+01	-0.1598161E+00
BV	0.1000000E+01	0.1204012E+01	-0.3119694E+00
BV	0.1000000E+01	0.1166467E+01	-0.1183618E+00
	0.1499988E+01	0.9966580E+00	-0.1939446E+00
	0.1499988E+01	0.1027320E+01	-0.3659835E+00
	0.1499988E+01	0.1082553E+01	-0.1958463E+00
BV	0.2000000E+01	0.9071650E+00	-0.1644560E+00
BV	0.2000000E+01	0.8557010E+00	-0.3144059E+00
BV	0.2000000E+01	0.9820085E+00	-0.2051469E+00
	0.2499988E+01	0.8218551E+00	-0.1952637E+00
	0.2499988E+01	0.7080753E+00	-0.2992899E+00
	0.2499988E+01	0.8692692E+00	-0.2615687E+00
BV	0.3000000E+01	0.6889194E+00	-0.3609821E+00
BV	0.3000000E+01	0.5452628E+00	-0.3841680E+00
BV	0.3000000E+01	0.7004653E+00	-0.4350157E+00
	0.3499988E+01	0.4393614E+00	-0.6527848E+00
	0.3499988E+01	0.3021439E+00	-0.6055679E+00
	0.3499988E+01	0.4157635E+00	-0.7165620E+00
BV	0.4000000E+01	0.3023940E-01	-0.9780172E+00
BV	0.4000000E+01	-0.6917900E-01	-0.8780972E+00
BV	0.4000000E+01	-0.1966124E-01	-0.1017653E+01

ORIGINAL
PAGE 1
OF 100
QUALITY

0.4499988E+01 -0.5202453E+00 -0.1192773E+01
0.4499988E+01 -0.5623034E+00 -0.1068457E+01
0.4499988E+01 -0.5823204E+00 -0.1201337E+01
BV 0.5000000E+01 -0.1120339E+01 -0.1156316E+01
BV 0.5000000E+01 -0.1100701E+01 -0.1038892E+01
BV 0.5000000E+01 -0.1178973E+01 -0.1134771E+01
0.5499988E+01 -0.1620719E+01 -0.7882960E+00
0.5499988E+01 -0.1549849E+01 -0.7044602E+00
0.5499988E+01 -0.1662591E+01 -0.7445205E+00
0.5999975E+01 -0.1856129E+01 -0.1093147E+00
0.5999975E+01 -0.1755411E+01 -0.7539177E-01
0.5999975E+01 -0.1873079E+01 -0.5561318E-01
0.6499963E+01 -0.1699487E+01 -0.7498049E+00
0.6499963E+01 -0.1595233E+01 -0.7306663E+00
0.6499963E+01 -0.1689939E+01 -0.7999821E+00
0.6999950E+01 -0.1111778E+01 -0.1575008E+01
0.6999950E+01 -0.1028616E+01 -0.1512332E+01
0.6999950E+01 -0.1080476E+01 -0.1610318E+01
0.7499938E+01 -0.1703979E+00 -0.2126056E+01
0.7499938E+01 -0.1256821E+00 -0.2038593E+01
0.7499938E+01 -0.1266947E+00 -0.2139690E+01
BV 0.8000000E+01 0.9355519E+00 0.2207460E+01
BV 0.8000000E+01 0.9350631E+00 0.2117948E+01
BV 0.8000000E+01 0.9803001E+00 0.2198301E+01
0.8499988E+01 0.1943652E+01 0.1732606E+01
0.8499988E+01 0.1902399E+01 0.1662101E+01
0.8499988E+01 0.1978937E+01 0.1704964E+01
0.8599975E+01 -0.2584519E+01 -0.7611817E+00
0.8599975E+01 -0.2515999E+01 -0.7242907E+00
0.8999975E+01 0.2603026E+01 0.7232467E+00
0.9499963E+01 0.2655359E+01 -0.5033556E+00
0.9499963E+01 0.2578136E+01 -0.5012513E+00
0.9499963E+01 0.2654379E+01 -0.5417817E+00
0.9999950E+01 0.2082677E+01 -0.1757649E+01
0.9999950E+01 0.2015577E+01 -0.1720763E+01
0.9999950E+01 0.2064295E+01 -0.1787580E+01
0.1043994E+02 0.9543520E+00 -0.2673926E+01
0.1049994E+02 0.9120432E+00 -0.2614173E+01
0.1049994E+02 0.9245045E+00 -0.2689205E+01
BV 0.1100000E+02 -0.4902712E+00 -0.2987630E+01
BV 0.1100000E+02 -0.5003040E+00 -0.2921115E+01
BV 0.1100000E+02 -0.5235552E+00 -0.2986093E+01
0.1149999E+02 -0.1911096E+01 -0.2573324E+01
0.1149999E+02 -0.1889607E+01 -0.2516190E+01
0.1149999E+02 -0.1939749E+01 -0.2556934E+01
0.1199998E+02 -0.2950666E+01 -0.1487803E+01
0.1199998E+02 -0.2905669E+01 -0.1452456E+01
0.1199998E+02 -0.2968460E+01 -0.1461786E+01
0.1249996E+02 -0.3325411E+01 -0.3404944E-01
0.1249996E+02 -0.3269627E+01 -0.4145324E-01
0.1249996E+02 -0.3329236E+01 -0.6272632E-01
0.1299995E+02 -0.2903874E+01 -0.1630794E+01
0.1299995E+02 -0.2851327E+01 -0.1611201E+01
0.1299995E+02 -0.2894167E+01 -0.1655208E+01
0.1349994E+02 -0.1749166E+01 -0.2902203E+01
0.1349994E+02 -0.1711786E+01 -0.2862759E+01
0.1349994E+02 -0.1729476E+01 -0.2917081E+01
0.1399993E+02 -0.1128939E+00 0.3511371E+01
0.1399993E+02 -0.9793961E-01 0.3463157E+01

0.1399993E+02	-0.8875316E-01	0.3514157E+01	
0.1449991E+02	0.1620042E+01	0.3274693E+01	
0.1449991E+02	0.1611238E+01	0.3229779E+01	
0.1449991E+02	0.1642606E+01	0.3265895E+01	
BV	0.1500000E+02	0.3023735E+01	0.2215452E+01
BV	0.1500000E+02	0.2995492E+01	0.2183982E+01
BV	0.1500000E+02	0.3039624E+01	0.2198212E+01

SAVE MATRIX

BOUNDARY VALUE,UNPTRBD SOLN, PTRBD SOLNS.....

1	0.100000E+01	0.100000E+01	0.100000E+01	0.100000E+01
2	0.221544E+01	0.221545E+01	0.218398E+01	0.219821E+01
3	0.302373E+01	0.302374E+01	0.299549E+01	0.303962E+01
4	-0.298664E+01	-0.298763E+01	-0.292111E+01	-0.298609E+01
5	-0.491267E+00	-0.490271E+00	-0.500304E+00	-0.523555E+00
6	0.220547E+01	0.220746E+01	0.211795E+01	0.219830E+01
7	0.937223E+00	0.935552E+00	0.935063E+00	0.980300E+00
8	-0.115294E+01	-0.115632E+01	-0.103889E+01	-0.113477E+01
9	0.259479E-01	0.302394E-01	0.691790E-01	-0.196612E-01
10	-0.364643E+00	-0.360982E+00	-0.384168E+00	-0.435016E+00
11	0.909266E+00	0.907165E+00	0.855701E+00	0.982008E+00
12	0.109366E-01	0.109050E+01	0.120401E+01	0.116647E+01
	1TH PIVOT	0.100000E+01	101	
	2TH PIVOT	-0.314703E-01	202	
	3TH PIVOT	0.313617E-01	303	

CONSTANTS 0.9993438E+00 0.3443009E-03 0.3118941E-03

DBT -0.8552962E+00 ANORM 0.7530599E-04

DIC VECTOR

0.6860495E-04 0.3105402E-04 0.0000000E+00 0.0000000E+00 0.0000000E+00

REPEATED TIMES ARE PARTICULAR SOLUTIONS

TIME	ITER	4	6F	4	
0.0000000E+00			SOLUTION		
0.4999996E+00	0.9973950E+00	0.4978837E+00	0.2000000E+00	0.1000000E+01	0.1000000E+01
BV	0.1000000E+01	0.1126198E+01	0.5437643E-01		
	0.1499988E+01	0.9966997E+00	-0.1940058E+00		
BV	0.2000000E+01	0.9071740E+00	-0.1645237E+00		
	0.2499988E+01	0.8218322E+00	-0.1953211E+00		
BV	0.3000000E+01	0.6888731E+00	-0.3610167E+00		
	0.3499988E+01	0.4393052E+00	-0.6527909E+00		
BV	0.4000000E+01	0.3018703E-01	-0.9779964E+00		
	0.4499988E+01	-0.5202802E+00	-0.1192725E+01		
BV	0.5000000E+01	-0.1120350E+01	-0.1156263E+01		
	0.5499988E+01	-0.1620708E+01	-0.7882488E+00		
	0.5999975E+01	-0.1856094E+01	-0.1092827E+00		
	0.6499963E+01	-0.1693442E+01	0.7498147E+00		
	0.6999950E+01	-0.1111734E+01	0.1574995E+01		
	0.7499938E+01	-0.1703653E+00	0.2126025E+01		
BV	0.8000000E+01	0.9355652E+00	0.2207417E+01		
	0.8499988E+01	0.1943647E+01	0.1732563E+01		
	0.8999975E+01	0.2584495E+01	0.7611488E+00		
	0.9499963E+01	0.2655319E+01	-0.5033699E+00		
	0.9999950E+01	0.2082635E+01	-0.1757638E+01		
	0.1049994E+02	0.9543239E+00	-0.2673894E+01		
BV	0.1100000E+02	-0.4902616E+00	-0.2987592E+01		
	0.1149999E+02	-0.1911094E+01	-0.2573289E+01		
	0.1199998E+02	-0.2950648E+01	-0.1487777E+01		
	0.1249996E+02	-0.3325378E+01	0.3406220E-01		
	0.1299995E+02	-0.2903840E+01	0.1630788E+01		
	0.1349994E+02	-0.1749135E+01	0.2902186E+01		
	0.1399993E+02	-0.1128750E+00	0.3511342E+01		
	0.1449991E+02	0.1620046E+01	0.3274663E+01		
BV	0.1500000E+02	0.3023725E+01	0.2215425E+01		